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EFFECT OF ACTIVITY-BASED METHOD ON PUPILS' PERFORMANCE IN BALANCING CHEMICAL EQUATIONS

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DECLARATION

Student's Declaration

I, **Philipina Tuffour,** declare that this thesis, with the exception of quotations and references contained in published works which have all been identified and duly acknowledged, is entirely my original work, and that it has not been submitted, either in part or whole, for another degree elsewhere nor in part been presented elsewhere.

Signature:………..…………………..…...

Date: …………………………………….

Supervisor's Declaration

I hereby declare that the thesis and its preparation and presentation of this work was supervised in accordance with guidelines for supervision of thesis as laid down by the University of Education, Winneba.

Supervisor's Name: **Prof. Arkoful Sam**

Signature:……………...………………...

Date: …………………………………….

DEDICATION

Glory be to God the highest for his protection and guidance throughout the study. To my lovely family and friends for their infringing support.

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ABBREVIATIONS

ABT	Activity Based Teaching
ZPD	Zone of Proximal Development
TLA	Teaching Learning Aids
SES	Socio Economic Status
SCIS	Student Centered Instructional Strategies
TCIS	Teacher Centered Instructional Strategies
APA	Grade Point Average
OECD	Organization for Economic Cooperation Development

ABSTRACT

The study assessed the effect of activity- based method on selected pupils' performance in balancing of chemical equations. It employed the action research design that involved pre-intervention, intervention and post intervention strategies. These strategies were used to ensure conceptual understanding in balancing chemical equations using three activities and a combination of three existing methods and to evaluate the effects of the method on 40 pupils' academic achievement at Socco H/H Basic School. Mixed method was the research approach employed by the researcher. A purposive sampling was done since an intact class was used to help achieve the set goal. Data collecting instrument such as interview guide, questionnaire, pre and post intervention test were also used. A descriptive statistic such as simple percentages with bar charts representation was used for the data analysis to evaluate the effect of the activity-based method on pupils' achievement in balancing of chemical equations. Originally, about 72% of the pupils found it difficult to write chemical formulae correctly but after the intervention, pupils performance improved drastically with 50% difference of the post intervention test scores and 13.62 mean difference of the post intervention test scores. To the researcher, the outcome of the findings showed that, the activities used in teaching balancing of chemical equations were very effective as pupils felt motivated to learn the supposed complicated concept in chemistry and their conceptual understanding and academic performance improved. The prepared module which was used at the intervention stage to ensure conceptual understanding could serve as a guide to the science teachers of Socco H/H Basic School in teaching balancing of chemical equation.

CHAPTER ONE

INTRODUCTION

1.0 Overview

This section looked at the background to the study which stated how important to teach learners at the concrete operational stage using the activity method. The statement of the problem which indicates why the researcher had interest in the study. The purpose of the study which is to assess the effect of the stated activity, Objectives, research questions, significance, limitations, delimitation and organization.

1.1 Background to the Study

In this era of globalization and technological revolution, education is considered to be of outmost importance in every human activity (Farooq, Chandry, Shafiq & Berhanu, 2011). It plays a vital role in the development of human capital and is linked to an individual's well-being and offer opportunities for better living. According to Okon-Enoh (2008), science is a way of seeking information (process) and also an accumulated knowledge resulting from research (products).

Thangavel (2019), asserts that, chemical equation is a written symbolic representation of a chemical reaction. The reactants chemical(s) on the left-hand side and the products chemical(s) on the right-hand side. In chemical equations, the number of atoms that are present in the reactants side must be equal to the number of atoms that are present in the products side to ensure that, the equation is balanced with the number of atoms to align with the law of conservation of mass which states that, no atoms can be created or destroyed in a chemical reaction.

Balancing of chemical equations is considered one of the frequent problems faced by chemistry students and scholars that are mostly solved by trial and error (Zabadi & Assaf, 2017). Nonetheless, there are existing methods of teaching the topic.

(Sarpong, Sarpong and Asor (2020), defined activity-based teaching as one that entails sparkling students' involvement in developing intelligence and self -reliance. The National Knowledge Commission (NKC, 2009) posited that, the activity-based teaching method used in teaching students provided them with the hope of solving practical problems using their resources. Studies have shown that, pupils taught through the activity-based approach can retain the concepts much longer than those taught without it Özen & Ergenekon, (2011). According to Kenneth (2014), The Activity-Based method of teaching is the preferred choice of science teaching and learning at the JHS level because it takes advantage of the Piaget's concrete operational developmental stages of knowledge construction. To the (American Association of the Advancement of Science [AAAS], 1990), Sarpong & Asor, (2020) demonstrated that, pupils at the concrete operational stage by nature show peculiar behaviors when at play or using materials within their environment and those students differ in demonstrating such behaviors due to their genetic and environmental factors. Hence, when the activity method is used in teaching science, individual students are allowed to form concept at their own pace, especially in balancing of chemical equation. This helps pupils to easily remember the concept learnt.

1.2 Statement of the Problem

It is very important to build good concepts that aid better understanding in pupils to ensure good learning practices (Bel-Ann, 2021). It is also the case that, pupils learn better when guided through methods of learning (Anwer, 2019).

On a routine monitoring of Socco HH Basic School within the Accra Metro Education Directorate by the researcher, it was noted that, pupils at JHS 2 were performing poorly in their integrated science test scores which needed an immediate attention. From the pupil's exercise books it was proven that, the pupils were unable to:

- Write the formulae of binary compounds,
- write a complete chemical equation,
- balance chemical equations correctly and
- identify the coefficients attached to compounds.

It is on these conceptual mindset deficit that, the researcher adopted activity-based methods in teaching Socco HH Basic School JHS 2 pupils balancing of chemical equation in order to enhance their achievement in chemical equation balancing.

1.3 Purpose of the Study

The purpose of the study was to assess the effect of activity-based method on the selected pupil's achievement in balancing chemical equations.

1.4 Objectives of the Study

The objectives of the study were to:

- Assess the pupils' conceptual difficulties in balancing chemical equations.
- assess the extent of pupils' knowledge of the principles underlying balancing of chemical equations.
- evaluate the effect of activity-based method on the pupils' performance in balancing chemical equations
- assess the pupils' perception of the use of the activity-based method in balancing of chemical equations.

1.5 Research Questions

The study was guided by the following research questions:

1. What are the pupils' conceptual difficulties in balancing chemical equations?
2. To what extent do the pupils know the principles underlying the balancing of chemical equations?
3. What are the effects of activity-based method of teaching on the pupils' performance in balancing chemical equations?
4. What are the pupils' perception of the use of the activity-based method in balancing chemical equations?

1.6 Significance of the Study

The study was intended to help pupils in Socco H/H Basic School within Accra Metro Education Directorate to balance chemical equations correctly. It was also to provide a suitable and effective method of teaching the fundamental concepts and facts that would enhance pupils understanding of the concept of balancing chemical equations. In addition, the study could be replicated in future and implementation of these findings would bring conceptual understanding to pupils in other schools.

1.7 Limitation of the Study

The major limitation of the study was inadequate time to work and collect data from the schools since the time table was loaded with activities. In addition, some of the respondents for the study were not present at school for all the lessons. Some respondents were dishonest in their responses as well as changing their behaviour towards the work. This did not however, in any away affect the quality of the research.

1.8 Delimitations of the Study

Much as the researcher would have loved to cover a greater proportion of Junior High Schools, the study was restricted to only one school in the Accra Metro in the Greater Accra Region. Again, the study focused on only one topic which is balancing of chemical equations. The researcher sought for the assistance of the science teachers in the school for effective work.

1.9 Organization of the Study

The study has been organized into five (5) chapters. Chapter one is the introduction which presents the background of the study, problem statement, research objectives, and research questions, scope of study, relevance and limitations of the study. Chapter two is a review of the relevant literature of the study. It looks at concepts and theories that relate to the research topic and research questions.

Chapter three describes the research methodology that was adopted. It outlines the research design, data collection techniques, the research instruments used, sampling technique, validity and reliability of instruments, and data analysis. Chapter four is a detailed account of the findings and results of the study. It discusses the researcher's analysis of the responses to the items in the pre-test and the post-test with the view to evaluating the effectiveness of the intervention design.

Chapter five, is on the conclusions that were drawn from the findings and recommendations made in order to enhance pupils' understanding of balancing of chemical equations using the table method as an intervention strategy.

CHAPTER TWO

LITERATURE REVIEW

2.0 Overview

This chapter dealt with the theoretical framework underpinning the study, having constructivist theory, activity theory and conceptual learning theory reviewed. The concept of chemical equation, principles underlying the balancing of chemical equations, existing methods of balancing chemical equations, the periodic table and the role it plays in the teaching of chemistry, challenges in studying balancing of chemical equations, factors affecting students' academic performance, formulae and IUPAC system of naming inorganic compounds and studies on chemical reactions were reviewed under conceptual framework.

2.1 Theoretical Framework Underpinning the Study

Arends (1998) stated that constructivism believes in the personal construction of meaning by the learner through experience and that meaning is influenced by the interaction of prior knowledge and new events. Constructivism is a theory propounded by Piaget (1972). The theory tries to explain how people acquire knowledge and learn. Pupils construct knowledge and meaning from their experiences (Kivinen, & Ristela, 2003). The researcher viewed Piaget's theory of constructivism as one which the, pupils produce knowledge and form meaning based upon their experiences. Piaget's theory covered learning theories, teaching methods, and education reform. Two of the key components which create the construction of an individual's new knowledge are accommodation and assimilation. Constructivism is 'an approach to learning that holds that people actively construct or make their own knowledge and that reality is determined by the experiences of the learner' (Elliott et al, 2000).

The researcher holds the view that, learners must actively be involved in the learning process to arrive at new knowledge acquisition which is based on previous experiences. Some schools of taught see learning in different dimensions, one school see learning as a social activity. Dewey (1938) posited that, learning is something we do together, in interaction with each other, rather than an abstract concept. For example, Vygotsky (1978) believed that, community plays a central role in the process of making meaning. For Vygotsky, the environment in which children grow up will influence how they think and what they think about. Thus, all teaching and learning is a matter of sharing and negotiating socially constituted knowledge. Vygotsky (1978) also stated that, cognitive development stems from social interactions from guided learning within the Zone of Proximal Development. (ZPD).

The researcher supports the idea that, learning is an active rather than a passive process. The passive view of teaching views the learner as 'an empty vessel' to be filled with knowledge. Constructivism states that learners construct meaning only through active engagement with the world (such as experiments or real-world problem solving).
Information may be passively received, but understanding cannot be, for it must come from making meaningful connections between prior knowledge, new knowledge, and the processes involved in learning. This notion is of great importance to the researcher hence the inclusion of the constructivist theory in the theoretical frame work.

2.1.1 Activity theory

Activity is the events that students are made to carry out with various concrete materials in order to make a concept (Baserer, 2020). Activity- Based Teaching (ABT) is a teaching structure which is in a significant and natural relation with behaviour, where the stimulants are used before and after behaviour, offering learning opportunities to students. (Pretti-Frontczak, et al, 2003; Pretti-Frontczak & Bricker; 2004; Özen &

Ergenekon, 2011). The ABT process comprises a style of teaching which is task oriented, learner centred and based on skill and perception. It also dwells on benefitting from the activities where various teaching techniques and methods are used. The purpose here is to attain the skills of analysing, applying and synthesizing. it is not regarded as the fact that students obtain the knowledge and adopt it. ABT is a method of teaching students how to think with their thinking structure peculiar to them, facilitating to find practical solutions for the problems they experience and making pupils in the developmental age attain self-confidence in order to facilitate learning Hee, (2005). ABT approach is one of the constructivist learning approaches which student can use in an active learning environment in the process of positive attitude and value attainment Aktepe, (2010). Training teachers as a preservice education aiming at constructivist learning approach, it is of importance to deal with theoretical and application dimensions. In this way, the activities developed with the components of active learning will lead to a more effective learning by including application dimension as well as theoretical knowledge and student will form their own concepts with bases on the activities and reach knowledge directly.

According to Hee, (2005) activity-based theory has the following principles.

1. Object-orientedness (this is not to be confused with object-oriented programming) People live in a reality that is objective in a broad sense: the things that constitute this reality have not only the properties that are considered objective according to natural sciences but socially/culturally defined properties as well.
2. Internalization/externalization. Distinction between internal and external activities. Internal activities cannot be understood if they are analysed separately from external activities, because they transform into each other. Internalization is the transformation of external activities into internal ones. Internalization

provides a means for people to try potential interactions with reality without performing actual manipulation with real objects (mental simulations, imaginings, considering alternative plans, etc.). Externalization transforms internal activities into external ones. Externalization is often necessary when an internalized action needs to be "repaired," or scaled. It is also important when a collaboration between several people requires their activities to be performed externally in order to be coordinated.

3. Mediation. Activity Theory emphasizes that human activity is mediated by tools in a broad sense. Tools are created and transformed during the development of the activity itself and carry with them a particular culture – historical remains from their development. So, the use of tools is an accumulation and transmission of social knowledge. Tool use influences the nature of external behaviour and also the mental functioning of individuals.
4. Development. In Activity Theory development is not only an object of study, it is also a general research methodology. The basic research method in Activity Theory is not traditional laboratory experiments but the formative experiment which combines active participation with monitoring of the developmental changes of the study participants. Ethnographic methods that track the history and development of a practice have also become important in recent work. The four basic principles are considered an integrated system, because they are related with each other and associated with various aspects of the whole activity. The researcher finds this theory very important as it is the main idea surrounding the study. The ABT employed, served as a stimulant which offer learners the opportunity to learn within their natural setting and deduce knowledge by themselves.

2.2 Conceptual Learning Theory

Fletcher, et al (2019,) asserted that, conceptual learning is a process in which learners organize concept-relevant knowledge, skills, and attitudes to form logical cognitive connections resulting in assimilation, storage, retrieval, and transfer of concepts to applicable situations, familiar and unfamiliar. They identified the following in connection with conceptual learning. Recognizing patterns in information, forming linkages with concepts, acquiring deeper understanding of concepts, developing personal relevance, and applying concepts to other situations. To Schendan (2012) Knowledge based on experience with the world is stored in semantic memory and none semantic (perceptual and motor) memory systems. Schendan also asserts that, general knowledge about meaning and conceptual representations is stored in semantic memory, a type of explicit memory system. While memory systems theory traditionally proposed that semantic memory resides in a modal module independent from sensorimotor systems in the anterior temporal lobe, recent theories of knowledge organizes all ground conceptual knowledge to some extent in sensorimotor, emotion, and mental state processing distributed across numerous brain structures, resulting in multiple semantic memory and none semantic knowledge networks. It is very important for the researcher to note that, Human symbolic functions emerge to some extent from interactions between language and mental simulation in semantic networks Schendan (2012).

An integrated understanding of important concepts is referred to as conceptual learning. Students who have a conceptual understanding are more knowledgeable than those who only know theoretical facts and procedures https;//blog. teachmint.com. They grasp why a concept is significant and how it can be applied in various situations. Information is put into a logical order that allows them to learn and understand new concepts by relating them to the concepts they already know. Retention is also aided by conceptual learning, as information and processes taught through comprehension are linked, they are easier to retain and use, and they may be recreated if forgotten. This assertion, to the researcher makes the conceptual learning theory a great topic to review.

Greeno (1998) posited that, Curricula can be designed so that concepts are learned in activities where they function and can thereby be understood as resources for practice. Jurow (2004) studied middle school students participating in project-based activities designed to teach them about mathematics of population modelling. Studies done by this author, started with observation and representational systems for modelling-like tables or graphs of fish population growth operate by conventions that have already been designed to record and summarize multiple, concrete instances. Thus, in conventional use, these systems provide powerful resources for generalizing. For example, looking at a graph of population values over time, a skilled reader sees an ordered progression of values and can make inferences about intervening events, trends, and what might happen to the population in the future. However, pupils must be introduced to these conventional uses in order to make representational systems useful to them to generalize about concept dynamic positions on issues.

In a different set of practices, the teacher and pupils of a classroom community adopt some version of the concept learning in displaying their knowledge. Using teaching learning aids (TLA) in teaching is important to be able to accomplish conceptual learning objectives. Although a simple tool is not the answer in and of itself, it can be a valuable tool in the teacher's hands. It can successfully be used to communicate numerous scientific and mathematical concepts; this will aid Students who go on to higher education apply what they have learnt. They can draw on what they have learned and apply it to new topics through conceptual learning. The researcher is of the view that, the use of TLA assists teachers and students in developing a thorough grasp of how concepts interact with one another and creating an exemplar that will empower them throughout their careers. Again, when students and teachers have a conceptual understanding of the concepts and their relation to one another, they begin to construct their exemplar, which will allow them to solve any problem throughout their careers.

2.3 Conceptual Framework

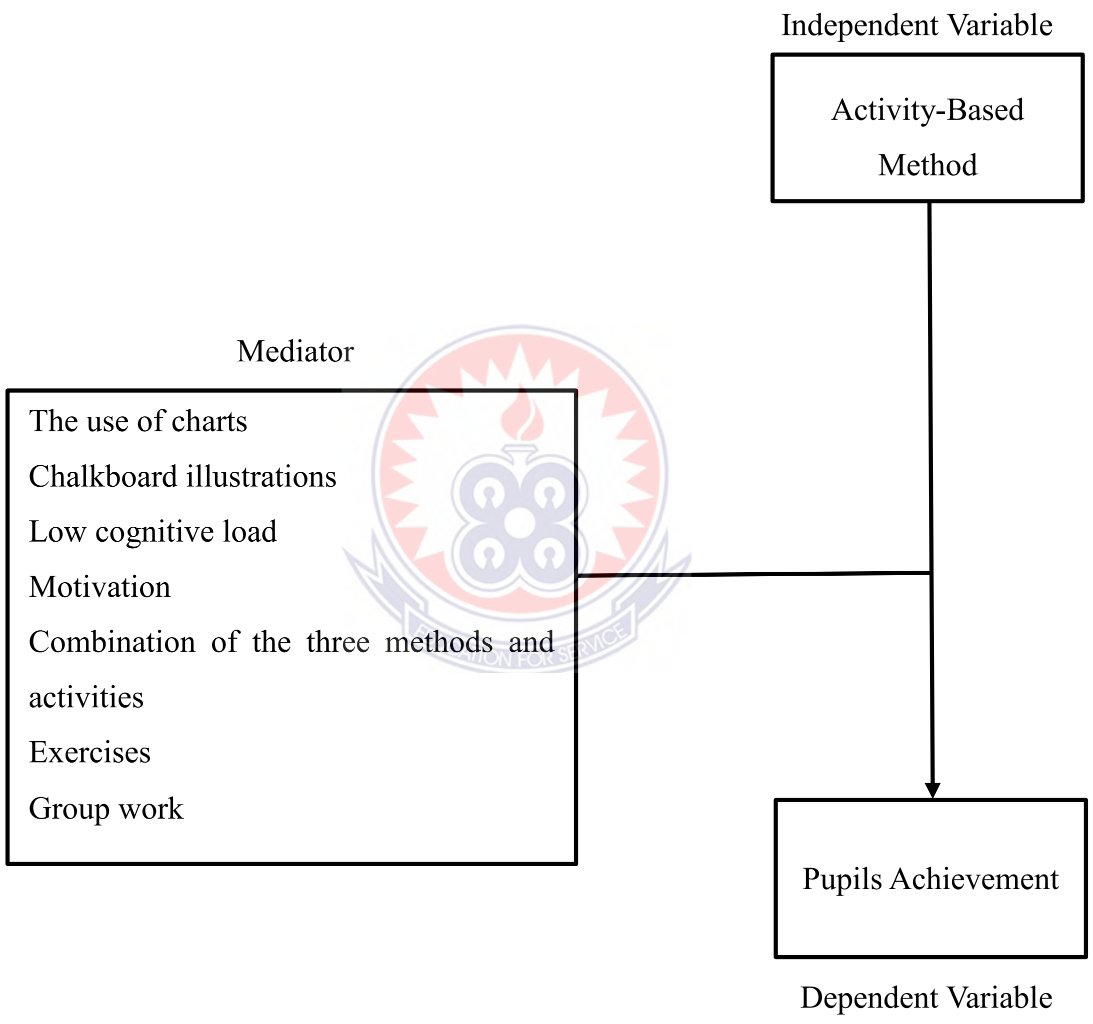


Figure 1: A diagram showing the conceptual framework

2.3.1 The concept of chemical equation

A chemical equation is a relationship between chemical reactants and the products they form during chemical reactions as represented by their chemical formulae (Sukius & Teleshou, 2019). They gave the contents of a chemical equation as the reactants (elements reacting with each other), products (elements produced in the reaction), and symbols that represent the relationships (plus signs and arrows). Here is their example of a chemical equation: **$2Na + 2HCl \rightarrow 2NaCl + H_2$.**

Risteski (2012) asserted that, balancing chemical reactions is an amazing subject matter for mathematics and chemistry students who want to see the power of linear algebra as a scientific discipline. Mass balance of chemical reactions is one of the most highly studied topics in chemical education. He added that, balancing chemical reactions offers a superb didactic example of interconnection between chemistry and linear algebra. Balancing chemical reaction is not chemistry; it is just linear algebra (Risteski, 2010). According to him, from a scientific view point, a chemical reaction can be balanced if and only if it generates a vector space. That is a necessary and sufficient condition for balancing a chemical reaction.

2.3.2 Principles underlying the balancing of chemical equations

When a substance undergoes a chemical reaction, chemical bonds are broken and new bonds are formed George (2020). This results in one or more new substances, often with entirely different properties. The "ingredients" or starting materials in a chemical reaction are referred to as reactants and the substances produced in the reaction are called products. A chemical Equation is a chemist's method of showing the changes in the arrangement of atoms that occur during a chemical reaction According to Staroscik (2011), chemical reaction is a set of compounds interact with each other to form new compounds. Chemists use equations to describe these interactions. Like mathematical equations, he added that, chemical equations conform to a set of rules which are:

- The reactants taking part in the reaction are written in terms of their symbols or molecular formulae on the left-hand side of the equation.
- A plus (+) sign is added between the formulae of the reactants.

- The products of reaction are written in terms of their symbols or molecular formulae on the right-hand side of the equation.

This allows equations to provide detailed information about a reaction. The author also gave the following as the characteristics of chemical reactions. Evolution of gas, formation of a precipitate, change in colour, change in temperature and change in state.

To Thangavel (2019), a chemical equation is a written symbolic representation of a chemical reaction. The reactants chemical(s) on the left-hand side and the products chemical(s) on the right-hand side. In chemical equations, the number of atoms that are present in the reactants side must be equal to the number of atoms that are present in the products side to ensure that, the equation is balanced with the number of atoms to align with the law of conservation of mass which states that, no atoms can be created or destroyed in a chemical reaction

Thangavel further gave the following as characteristics of a balanced equation:

- in a balanced chemical equation, the reactants and products have the same number of atoms of different elements.
- in an unbalanced chemical equation, there are unequal numbers of atoms of one or more elements in the reactants and products.
- in a balanced chemical equation, the reactants and products have equal masses of different elements.
- In an unbalanced equation, the reactants and products have unequal masses of different elements.
- the number of atoms of different types in the reactants should be equal to the number of atoms of the same type in the products.
- the chemical equations are balanced to satisfy the law of conservation of mass in a chemical reaction.

2.3.3 Stoichiometric coefficient

According to Parth (2002), the number of molecules involved in a process is known as the stoichiometric coefficient or stoichiometric number. A critical look at a balanced reaction indicates that, both sides of the equation have the same number of elements. The number in front of atoms, molecules, or ions is known as the stoichiometric coefficient. The author indicated that, fractions and whole numbers can both be used as stoichiometric coefficients. The factors essentially assist us in determining the mole ratio between reactants and products. He proceeded further to state the steps in writing a balanced chemical equation as follows:

Step 1: Write down the number of atoms in each element

Begin by counting and noting the number of atoms of each element on both sides of the reaction, as previously stated. Consider the reaction of nitrogen in the atmosphere with hydrogen. The two react to produce ammonia (NH_3), which is known as the 'Haber-Bosch process.' This reaction's imbalanced equation is:

$$N_2 + H_2 \rightarrow NH_3$$

According to the equation, two nitrogen atoms combine with two hydrogen atoms to generate a single molecule of ammonia. Ammonia, on the other hand, has three hydrogen atoms, whereas the reactant only has two. The reactant side also has one more nitrogen atom than the product side. The equation is unbalanced and violates the law of mass conservation.

Step 2: Begin with the important component

Always put hydrogen and oxygen atoms last when balancing a chemical equation (as they are often present on both sides). Begin with choosing an element that only appears in one of the reactants and one of the products.

The only element other than hydrogen in our example is nitrogen, therefore let us balance it out. The reactant side has two nitrogen atoms, while the product side has only one. The number of nitrogen atoms in ammonia can be balanced by simply multiplying it by two. The following is the new equation:

$N_2 + H_2 \rightarrow 2NH_3$

With two nitrogen atoms on each side, nitrogen is now balanced. Next, let us talk about hydrogen.

Step 3: Balance oxygen and hydrogen atoms

We balance the hydrogen and oxygen atoms in the final stage. According to our table, the number of hydrogen atoms on the product side has increased to 6, while the reactant side still has only two. How do we get from 2 to 6? By a factor of three. So let us get started,

$N_2 + 3H_2 \rightarrow 2NH_3$

There are 6 hydrogen atoms on each side, as a result, hydrogen is in equilibrium and 2 nitrogen atoms on both sides indicates a balanced chemical equation.

Brown, et al (2012) also defined Stoichiometry as the calculation of relative quantities of reactants and products in chemical reactions. They added that, Stoichiometric is founded on the law of conservation of mass where the total mass of the reactants equals the total mass of the products leading to the insight that the relations among quantities of reactants and products typically form a ratio of positive integers. They again gave the following as the elements of stoichiometric:

- a stoichiometric coefficient describes the total number of molecules of a chemical species that participate in a chemical reaction.
- it provides a ratio between the reacting species and the products formed in the reaction.

- in the reaction described by the equation $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$, the stoichiometric coefficient of O_2 and H_2O is 2 whereas that of CH_4 and CO_2 is 1.
- the total number of atoms of an element present in a species (in a balanced chemical equation) is equal to the product of the stoichiometric coefficient and the number of atoms of the element in one molecule of the species.
- for example, the total number of oxygen atoms in the reacting species '$2O_2$' is 4.

While balancing chemical equations, stoichiometric coefficients are assigned in a manner that balances the total number of atoms of an element on the reactant and product side. Helmenstine (2020) additionally identified the following 5 steps for balancing chemical equations as indicated below:

- identify each element found in the_equation. The number of atoms of each type of atom must be the same on each side of the equation once it has been balanced.
- what is the net charge on each side of the equation? The net charge must be the same on each side of the equation once it has been balanced.
- if possible, start with an element found in one compound on each side of the equation. Change the coefficients (the numbers in front of the compound or molecule) so that the number of atoms of the element is the same on each side of the equation. Remember, to_balance_an_equation, you change the coefficients,not the subscripts in the formulas.
- once you have balanced one element, do the same thing with another element. Proceed until all elements have been balanced. It's easiest to leave elements found in pure form for last.
- check your work to make certain the charge on both sides of the equation is also balanced.

2.4 Existing Methods of Balancing Chemical Equations

2.4.1 The inspection method

According to Thangavel (2019) chemical equation, no matter how complicated, can be balanced by inspection. In fact, inspection is often the quickest and easiest way to balance complex equation. It does not require the use of oxidation numbers of the splitting of equations into "half reactions". It can also be used to balance all kinds of chemical equations, including ionic equations. To Thangavel, balancing chemical equations by inspection is not a trial-and-error process, because a systematic procedure for the balancing simple and more complicated chemical equations without oxidation numbers or equations with several unknowns can be suggested. The proposed method is suitable for balancing all the chemical equations.

Charnock (2016) asserted that, two predominant methods are typically employed to convey a systematic method of chemical reaction balancing: (a) by inspection or (b) with a linear algebraic method. To him, balancing chemical equations by inspection is suitable in balancing situations with both simple and advanced reactions that are free from formal charges or those with several unknown factors. Charnock added that, the balance-by-inspection method is generally described using six steps with minor variations in preferential format from author to author and is depicted as follows:

1. from the skeleton equation, the problem solver creates a list of each element participating in the reaction and separates the list into two columns, one for reactants and a second for products.
2. balance metals (except hydrogen)
3. balance the non-metals (except oxygen)
4. balance oxygen
5. balance hydrogen

6. recount all atoms (checking step)

In Example 1:

$$Zn + HCl \rightarrow ZnCl_2 + H_2$$

Thus, from the unbalanced equation, the list would consist of……as shown in Table 1-4.

Table 1: Unbalanced Equation Atomic Inventory

Reactants		Products	
Element	**Quantity**	**Element**	**Quantity**
Zn	1	Zn	1
Cl	1	Cl	2
H	1	H	2

Now, to systematically apply the rules imposed by inspection methodology

Table 2: Rule 2 Balance the Metals (Except Hydrogen)

Reactants		Products	
Element	**Quantity**	**Element**	**Quantity**
Zn	1√	Zn	1√
Cl	1	Cl	2
H	1	H	2

Table 3: Rule 3 Balance the Non-metals (Except Oxygen)

Reactants		Products	
Element	**Quantity**	**Element**	**Quantity**
Zn	1√	Zn	1√
Cl	~~1~~2√	Cl	2√
H	1	H	2

Table 4: Rule 5 Balance Hydrogen

Reactants		Products	
Element	**Quantity**	**Element**	**Quantity**
Zn	1√	Zn	1√
Cl	~~1~~2√	Cl	2√
H	~~1~~ 2√	H	2 √

Rewriting the chemical equation for the balanced condition imposed by the result the final solution for equation $Zn + 2HC1 \rightarrow ZnCl_2 + H_2$

2.4.2 The traditional balancing method

The first step that must be followed while balancing chemical equations is to obtain the complete balanced equation (Breslyn, 2017). He gave the combustion reaction between propane and oxygen as an example as follows;

Step 1

- The unbalanced equation must be obtained from the chemical formulae of the reactants and the products (if it is not already provided).
- The chemical formula of propane is C_3H_8. It burns with oxygen (O_2) to form carbon dioxide (CO_2) and water (H_2O)
- The unbalanced chemical equation can be written as $C_3H_8 + O_2 \rightarrow CO_2 + H_2O$

Step 2

In his view, the total number of atoms of each element on the reactant side and the product side must be compared. For this example, the number of atoms on each side can be tabulated as follows:

Chemical Equation: $C_3H_8 + O_2 \rightarrow CO_2 + H_2O$	
Reactant Side	**Product Side**
3 Carbon atoms from C_3H_8	1 Carbon atom from CO_2
8 Hydrogen atoms from C_3H_8	2 Hydrogen atoms from H_2O
2 Oxygen atoms from O_2	3 Oxygen atoms, 2 from CO_2 and 1 from H_2O

Step 3

He reiterated that, stoichiometric coefficients are added to molecules containing an element which has a different number of atoms in the reactant side and the product side. The coefficient must balance the number of atoms on each side. Generally, the stoichiometric coefficients are assigned to hydrogen and oxygen atoms last. Now, the number of atoms of the elements on the reactant and product side must be updated. It is important to note that the number of atoms of an element in one species must be obtained by multiplying the stoichiometric coefficient with the total number of atoms of that element present in 1 molecule of the species. For example, when the coefficient 3 is assigned to the CO_2 molecule, the total number of oxygen atoms in CO_2 becomes 6. In this example, the coefficient is first assigned to carbon, as tabulated below.

Chemical Equation: $C_3H_8 + O_2 \rightarrow 3CO_2 + H_2O$	
Reactant Side	**Product Side**
3 Carbon atoms from C_3H_8	3 Carbon atoms from CO_2

8 Hydrogen atoms from C_3H_8	2 Hydrogen atoms from H_2O
2 Oxygen atoms from O_2	7 Oxygen atoms, 6 from CO_2 and 1 from H_2O

Step 4

Step 3 is repeated until all the number of atoms of the reacting elements are equal on the reactant and product side Breslyn (2017). He transformed the chemical equation as follows:

Chemical Equation: $C_3H_8 + O_2 \rightarrow 3CO_2 + 4H_2O$	
Reactant Side	**Product Side**
3 Carbon atoms from C_3H_8	3 Carbon atoms from CO_2
8 Hydrogen atoms from C_3H_8	8 Hydrogen atoms from H_2O
2 Oxygen atoms from O_2	10 Oxygen atoms, 6 from CO_2 and 4 from H_2O

Now that the hydrogen atoms are balanced, the next element to be balanced is oxygen. There are 10 oxygen atoms on the product side, implying that the reactant side must also contain 10 oxygen atoms. Each O_2 molecule contains 2 oxygen atoms. Therefore, the stoichiometric coefficient that must be assigned to the O_2 molecule is 5. The updated chemical equation is tabulated below.

Chemical Equation: $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$	
Reactant Side	**Product Side**
3 Carbon atoms from C_3H_8	3 Carbon atoms from CO_2
8 Hydrogen atoms from C_3H_8	8 Hydrogen atoms from H_2O
10 Oxygen atoms from O_2	10 Oxygen atoms, 6 from CO_2 and 4 from H_2O

Step 5

- Once all the individual elements are balanced, the total number of atoms of each element on the reactant and product side are compared once again.
- If there are no inequalities, the chemical equation is said to be balanced.
- In this example, every element now has an equal number of atoms in the reactant and product side.
- Therefore, the balanced chemical equation is $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$.

2.4.3 The algebraic balancing method

This method of balancing chemical equations involves assigning algebraic variables as stoichiometric coefficients to each species in the unbalanced chemical equation Hamid (2019). These variables are used in mathematical equations and are solved to obtain the values of each stoichiometric coefficient. In order to better explain this method, the reaction between glucose and oxygen that yields carbon dioxide and water has been considered as an example.

Step 1

- The unbalanced chemical equation must be obtained by writing the chemical formulae of the reactants and the products.

- In this example, the reactants are glucose ($C_6H_{12}O_6$) and oxygen (O_2) and the products are carbon dioxide (CO_2) and water (H_2O)
- The unbalanced chemical equation is $C_6H_{12}O_6 + O_2 \rightarrow CO_2 + H_2O$

Step 2

Now, algebraic variables are assigned to each species (as stoichiometric coefficients) in the unbalanced chemical equation. In this example, the equation can be written as follows:

a. $\mathbf{C_6H_{12}O_6}$ + b. $\mathbf{O_2}$ → c. $\mathbf{CO_2}$ + d. $\mathbf{H_2O}$

Now, a set of equations must be formulated (between the reactant and product side) in order to balance each element in the reaction. In this example, the following equations can be formed.

The equation for Carbon

- On the reactant side, 'a' molecules of $C_6H_{12}O_6$ will contain '6a' carbon atoms.
- On the product side, 'c' molecules of CO_2 will contain 'c' carbon atoms.
- In this equation, the only species containing carbon are $C_6H_{12}O_6$ and CO_2.

Therefore, the following equation can be formulated for carbon: $\mathbf{6a = c}$

The equation for Hydrogen

- The species that contain hydrogen in this equation are $C_6H_{12}O_6$ and H_2
- 'a' molecules of $C_6H_{12}O_6$ contains '12a' hydrogen atoms whereas'd' H_2O molecules will contain '2d' hydrogen atoms.
- Therefore, the equation for hydrogen becomes $\mathbf{12a = 2d}$.

Simplifying this equation (by dividing both sides by 2), the equation becomes: $\mathbf{6a = d}$

The equation for Oxygen. Every species in this chemical equation contains oxygen. Therefore, the following relations can be made to obtain the equation for oxygen:

- for ‘a’ molecules of $C_6H_{12}O_6$, there exist ‘6a’ oxygen atoms.
- ‘b’ molecules of O_2 contain a total of ‘2b’ oxygen.
- ‘c’ molecules of CO_2 contain ‘2c’ number of oxygen atoms.
- ‘d’ molecules of H_2O hold ‘d’ oxygen atoms.

Therefore, the equation for oxygen can be written as:

6a + 2b = 2c+ d

Step 3

The equations for each element are listed together to form a system of equations. In this example, the system of equations is as follows:

6a = c (for carbon); **6a = d** (for hydrogen); **6a + 2b = 2c + d** (for oxygen)

This system of equations can have multiple solutions, but the solution with minimal values of the variables is required. To obtain this solution, a value is assigned to one of the coefficients. In this case, the value of a is assumed to be 1. Therefore, the system of equations is transformed as follows: **a = 1**, **c = 6a = 6*1 = 6**, **d = 6a = 6**

Substituting the values of a, c, and d in the equation **6a + 2b = 2c + d**, the value of ‘b’ can be obtained as follows: 6*1 + 2b = 2*6 + 6 2b = 12; **b = 6**

It is important to note that these equations must be solved in a manner that each variable is a positive integer. If fractional values are obtained, the lowest common denominator between all the variables must be multiplied with each variable. This is necessary because the variables hold the values of the stoichiometric coefficients, which must be a positive integer.

Step 4

- Now that the smallest value of each variable is obtained, their values can be substituted into the chemical equation obtained in step 2.
- Therefore, $aC_6H_{12}O_6 + bO_2 \rightarrow cCO_2 + dH_2O$ becomes: $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$

  Thus, the balanced chemical equation is obtained.

The author asserts that, the algebraic method of balancing chemical equations is considered to be more efficient than the traditional method. However, it can yield fractional values for the stoichiometric coefficients, which must then be converted into integers. To Hamid (2019), balancing chemical equation by inspection is often believed to be a process that can be used only for simple chemical reactions but still it has limitations, in that, it does not produce a systematic evaluation of all the sets of coefficients that would potentially balance an equation. The author was quick to note that, the algebraic approach to balancing both simple and advance chemical reactions typically uncounted in the secondary chemistry classroom is superior to the inspection method. The author's justification was that; coefficients are treated as unknown variables or undetermined coefficients whose values are found by solving a set of simultaneous equations. The researcher shares the same view with the author that, a chemical equation can only be balanced if only it generates a vector space which is necessary and sufficient condition for balancing a chemical reaction.

From the researcher's view point, there are generally three (3) methods of balancing chemical equations. Inspection method, Simple method Algebraic method. The inspection method is just observing the various elements and assigning numerals until they are balanced. Writing your thoughts down in so as to keep on track while assigning the numerals sends us to the simple method. The Algebraic method has to do with complex equations to her, it is always good to combined some of these methods to teacher to be able to impact positively on your learners.

2.5 The Periodic Table and the Role it Plays in the Teaching and Learning of Chemistry

The periodic table is a tabular arrangement of the chemical elements. It is organized in order of increasing atomic number. There is a recurring pattern called the "periodic law" in their properties, in which elements in the same column (group) have similar properties within the periodic table Canham (2020). To the author, the chemical properties of the atom are determined by the number of protons, in fact, by number and arrangement of electrons. The configuration of these electrons follows from the principles of quantum mechanics. The number of electrons in each element's electron shells, particularly the outermost valence shell, is the primary factor in determining its chemical bonding behavior. In the periodic table, the elements are listed in order of increasing atomic number Z.

According to Siegfried (2019), no cause for celebration surpasses the origin of the periodic table of the elements, created 150 years ago this March by the Russian chemist Dmitrii Ivanovich Mendeleev. The author further added that, Mendeleev's table has become as familiar to chemistry students as spreadsheets are to accountants. It summarizes an entire science in 100 or so squares containing symbols and numbers. More so, it enumerates the elements that compose all earthly substances, arranged so as to reveal patterns in their properties, guiding the pursuit of chemical research both in theory and in practice.

Mendeleev's periodic table, published in 1869, was a vertical chart that organized 63 known elements by atomic weight. This arrangement placed elements with similar properties into horizontal rows. The title, translated from Russian, reads: "Draft of system of elements: based on their atomic masses and chemical

The Oxford dictionary also defined the periodic table as a table of the chemical elements arranged in order of atomic number, usually in rows, so that elements with similar atomic structure (and hence similar chemical properties) appear in vertical columns.

To Helmenstine (2020), the periodic table is important because

- It is organized to provide a great deal of information about elements and how they relate to one another in one easy-to-use reference.
- The table can be used to predict the properties of elements, even those that have not yet been discovered.
- Columns (groups) and rows (periods) indicate elements that share similar characteristics.
- The table makes trends in element properties apparent and easy to understand.
- The table provides important information used to balance Chemical Equation.

2.6 Challenges in Studying Balancing of Chemical Equations

Lacking essential knowledge of the primary chemistry concepts, which needed to be learnt and mustered at lower secondary levels is detrimental Ali (2012). The author added that, pupils seemed confused despite teacher's good efforts to communicate the concept using a variety of simple examples and explanations. This indicates that, unless student's grasp initial basic concepts in learning, they may not be able to cope with the advanced level knowledge. This underscores the critical importance of students' learning basic science concepts in the early stages with understanding.

Ali (2012) asserted that, Students' learning of subject matter with deeper understanding may not take place in the classroom in an isolated fashion. In-depth leaning is closely connected with various conditions inside and outside the classroom. He then called for synchronization and integration of efforts on the part of the school community as a whole. He added that, Schools need to create situations where teachers are encouraged to reflect on their own practices and engage in efforts to improve their general as well as subject-based pedagogical skills. The high demands of conceptual learning require chemistry teachers to letting go of transmission-oriented practices; they need to carefully prepare lesson plans, student worksheets, assignments, and assessment tasks to be able to think about and convey the subject matter in different ways.

To Ali, the recognition of the teacher's vital facilitative role in in-depth student learning necessitates the use of effective equipment by teachers with professional competencies (knowledge, skills, and disposition). He added that, Unfortunately, most traditional pre- and in-service teacher training program in Pakistani context do not provide necessary conditions to help inculcate and nurture these critical professional qualities in teachers. The researcher also shares same sentiments when it comes to Ghana. The training must entail a new vision of education and professional growth for teacher compatible with a vision of pedagogy.

2.7 Factors Affecting Students' Academic Achievement in Chemistry

Various factors have been given for poor performance of pupils. Rothstein (2000) argued that learning is not only a product of formal schooling but also of communities, families and peers. Socio-economic and socio-cultural forces can affect learning and thus school achievement. The next part focuses on the relative effects of home-related, school-related, student characteristics, and teacher-side factors that affect students' academic performance.

2.7.1 Home-related factors

Whether a student performs well in school can be influenced by a range of household factors. These include socio-economic status (education, occupation and income), size of the household, type of discipline at home, family structure, and the level of parental involvement and interest in student schooling are all factors which affect performance in school.

2.7.2 Family background

Majoribanks (1996) holds the view that family is the key to a student's life outside of school; it is the most important influence on students' learning and includes factors such as socioeconomic status and family structure. The environment at home is a primary socialization agent and influences a child's interest in school and aspirations for the future. Osuafor (2013) noted that family background including family structure, parental occupation and parental education level had a significant influence on students' achievement in biology. Further, McIntosh (2008) in his study concluded that in Canada, children who came from low-income households, having divorced or separated parents, would actually perform better than average scores if they came from homes that had positive attitudes and that strongly supported their children. This was supported by another study on Children and Youth in Canada that was carried out by Rothstein (2000) who reported that, there was a significant effect of family background variables, parental support, and teacher support on a child's educational achievement. The relationship between parental resources on the academic performance of children has received a great deal of attention in the economic literature in African Countries. For instance, Guo and Harris (2002) observed that in Ghana and South Africa states, students' performance in school was strongly associated with their parents' educational attainments. The researcher is of the view all things being equal, students from homes of good environment by all standards do well in school.

2.7.3 Socio-economic status (SES)

Majoribank (1996) SES as a person's overall social position to which attainments in both the social and economic domain contribute. To the author, when used in studies of students' school achievement, it refers to the SES of the parents" or family educational level, occupational level and income level of the parents or family. According to the researcher, several comprehensive reviews of the relationship between SES and educational outcomes exist. These studies make it clear that, those children from low socio-economic families are more likely to exhibit the following patterns in terms of educational outcomes as compared to children from high SES families: have lower levels of literacy, numeracy, comprehension and lower retention rates, earn lower test scores and are likely to drop out of school. The also exhibit higher levels of problematic school behaviour, for instance; truancy and are more likely to have difficulties with their studies and display negative attitudes towards school.

Similarly, studies of pupil's educational achievements over time have also demonstrated that social background remains one of the major sources of educational inequality. In other words, educational success depends very strongly on the socio- economic status of one's parents. The effect of parental SES on pupil's educational outcomes according to Barry (2005) may be neutralized, strengthened or mediated by a range of other contextual, family and individual characteristics. Parents may have a low income and a low-status occupation, for example, but nevertheless transmit high educational aspirations to their children (Osei-Mensah, 2012). What family members have (material resources) can often be mediated by what family members do (for example parental support, family cohesion). The social and the economic components of SES, in other words, may have distinct and separate influences on educational outcomes. While both components are important, social factors (for instance, parents" educational attainments) have been found to be more significant than economic factors, such as a family's capacity to purchase goods and services, in explaining different educational outcomes (Osei-Mensah, 2012).

2.7.4 School-related factors

Several school environmental factors have generally been identified as influencing academic performance. These include availability of instructional materials, school location and quality of the physical facilities, class size and pupil-teacher ratios, teacher qualification and experience, and supervision.

2.7.5. Learning environment

Barry (2005) holds the view that, a student's educational outcome and academic success is greatly influenced by the type of school they attend. In his view, the school one attends is the institutional environment that sets the parameter of a student's learning experience. Depending on the environment a student can either close or open the doors that lead to academic achievement.

A learning environment that is free of barriers, or obstacles or distractions such as noise, gas/smoke pollutions and so on can constitute health hazards, which in turn affect or reduce the student's concentration or conceptual focus to learning. According to Barry (2005), markets and garages located near schools have always posed a threat to students. Noise and pollution from these sources have always endangered students' life and concentration. Therefore, for an effective learning and high academic performance, schools in both rural and sub-urban and urban areas should be located off zones characterized with smoke/gas pollutions, market centers or garages, as conducive learning environments stimulate learning, understanding and high perception (Osei-Mensah, 2012).

Crosnoe, et al (2004) have suggested that school sector (public or private) and class size are two important structural components of schools. Private schools tend to have better funding and smaller class size than public schools especially in Ghana. The additional funding of Private schools leads to better academic performance and more access to resources such as computers, which have been shown to enhance academic achievement (Eamon, 2005). Smaller class size creates more intimate setting and therefore can increase teacher-students bonding which has also been shown to have a positive effect on students' success. According to Danesy (2004), other factors that compliment environmental and socio-economic factors to produce high academic achievements and performance include good teaching, counselling, good administration, good seating arrangement and good building. Dilapidated buildings, lacking mentally stimulating facilities that are characterized with low or no seating arrangements are also destructive to students' academic achievement.

Danesy (2004) indicated that innovative environments do stimulate head start learning and mental perception. It has also been proved that students who come from simulative environments with laboratory equipment or those that are taught with rich instructional aids and pictures perform better than those trained without them (Osei- Mensah, 2012). This implies that teaching and learning should be done under organized, planned, and fortified environment with learning instructional aides to stimulate students' sense of conception, perception and concentration to facilitate systematic understanding and acquisition of knowledge in them.

In the view of the researcher, a combination of a healthy family background, good environment plus the child being educated in a conducive environment with a fortified learning or instructional aids or motivational incentives prompt academic performance whiles a lack of this will retard academic performance.

2.7.6 Instructional materials

Instructional materials provide information, organize the scope and sequence of the information presented, and provide opportunities for students to use what they have. Students usually perform better when they have books or study aids to foster their learning. These study aids or material resources could be textbooks, teachers' guides, wall pictures, maps, atlases and other learning aids. The availability and use of teaching and learning materials affect the effectiveness of a teacher's lessons during instructional delivery.

Moreover, the school location and quality of the physical building influence the performance and achievement levels of students. Harbison and Hanushek (1992) stated that the quality of the physical facilities is positively related to student performance. This assertion buttresses that of Danesy (2004) who stressed that good sitting arrangement and good buildings produce high academic achievements and performance, while dilapidated buildings that lack mental stimulating facilities coupled with low or no sitting arrangements is destructive.

According to Asikhia (2010) where the school is located determines to a very large extent the patronage such a school will enjoy. Equally, the entire unattractive physical structure of the school building could de-motivate learners to achieve academically. This is what Isangedighi (1998) referred to as learner's environment mismatch.

According to author, this promotes poor academic achievement. Engin-Demir (2009) argued that attending a school with a better physical environment is associated with increased mathematics scores. Adepoju (2001) found that pupils in urban schools manifest more brilliant performance than their rural counterparts. Also, Ogunleye (2002) revealed a significant difference in the achievement of students in urban peri-urban areas.

Furthermore, schools with effective supervision of teaching and learning activities have high performance rates. Etsey, et al (2004) in a study of 60 schools from peri-urban (29) and rural (31) schools in Ghana, pupils were found to be performing better academically in private schools than public schools because of more effective supervision of work. According to Etsey (2005) if circuit supervisors are more regular in schools, it would put the teachers on the alert to be more regular and early in school. This would forestall teacher absenteeism and improve teaching in the schools. If teachers are present always following regular visits of circuit supervisors, students would be challenged to change their attitudes toward school.

2.7.7 Learning facilities and academic achievement

School facilities have been observed as a potent factor to quantitative education. The importance to teaching and learning from the provision of adequate instructional facilities for education cannot be over-emphasized. The dictum that "teaching is inseparable from learning but learning is not separable from teaching" is that teachers do the teaching to make the pupils learn, but students can learn without the teachers.

According to Akande (1985), learning can occur through one's interaction with one's environment. Environment here refers to facilities that are available to facilitate pupils learning outcome. It includes books, audio-visual, software and hardware of educational technology; so also, size of classroom, sitting position and arrangement, availability of tables, chairs, chalkboards, shelves on which instruments for practical lessons are arranged.

Oni (1992) asserted that, facilities constitute a strategic factor in organizational functioning. This is so because they determine to a very large extent the smooth functioning of any social organization or system including education. He further stated that their availability, adequacy and relevance influence efficiency and high productivity. In their words, Ajayi and Ogunyemi (1990) opined that the wealth of a nation or society could determine the quality of education in that land; emphasizing that a society that is wealthy will establish good schools with quality teachers, learning infrastructures that with such, students may learn with ease thus bringing about good academic achievement. Writing on the role of facilities in teaching. Ajayi and Ogunyemi (1990) reiterated that when facilities are provided to meet relative needs of a school system, students will not only have access to the reference materials mentioned by the teacher, but individual students will also learn at their own paces. The net effect of this is increased overall academic performance of the entire students. Adesina (1981) identified poor and inadequate physical facilities, obsolete teaching techniques and overcrowded classrooms among others, as factors.

Throwing more light on school facilities and moral guiding provision, Fabunmi (1997) asserted that school facilities when provided will aid teaching and learning programs and consequently improve academic achievement of students while the models guiding their provision to schools could take any form as rational bureaucratic and or political model. Whichever model is adopted, according to him, is always a common feature of differing allocation of facilities to schools. Ojoawo (1990) however, noted that certain schools are favoured in the allocation of facilities at the expense of others. Writing on poor performance of students in public examinations, Akinkugbe (1994) opined that everywhere you look, primary, secondary, special, technical, tertiary, there is abundant evidence of crippling inertia, criminal neglect and a pervasive decay in values and standard. Other scholars have variously identified the significance of facilities in teaching learning spheres. The researcher can thus say that absence or poor (and or deteriorating) quality of educational facilities can affect academic performance.

2.7.8 Teacher-factors

The researcher believes several teacher factors influence academic performance of pupils. These include teacher attendance in school, teacher's interest and motivation, teaching effectiveness, methods of teaching, teaching experience etc.

Teacher regularity in school is important in terms of both children's access to education and the nature of that access (Osei-Mensah, 2012). A widespread problem of teacher absenteeism is likely to contribute to poor student performance. The prevailing evidence is that teacher absenteeism in Ghana appears to have worsened in the last fifteen years (World Bank, 2004). The World Bank impact evaluation education in Ghana found that, "in 2003, nearly 13 per cent of teachers had been absent in the past month, compared to just over 4 per cent in 1988" (World Bank, 2004). It also uncovered that "in 1988, 85 per cent of schools did not suffer at all; whereas this figure fell to 61 per cent, with 13 per cent of schools with over one-third of the teachers being absent for reasons other than sickness in the past month" (World Bank, 2004).

The study also found nonattendance to be significantly worse in rural schools than in urban schools, and worse in public schools compared to private schools. Also, the CARE International (2003) report which looked at deprived rural areas in northern Ghana talked of "chronic teacher absenteeism" which "adversely affects the learning environment" high rates of lateness, absenteeism and sometimes refusing to teach during classes.

The World Bank (2004) report put forward a number of reasons for the increasing teacher absenteeism in Ghanaian schools. These included teachers living long distances from schools and experiencing transportation difficulties; teachers having to travel to town once a month to collect their pay, which may or may not have arrived; and, rural teachers engaging in farming activities.

Although factors were context-specific, multivariate analysis on teacher survey data in Ghana also indicated that teacher absenteeism was more likely to occur if the following factors were prevalent: poor working conditions, low morale, and high pupil- teacher ratio, living with spouse, being in their home district, and having good social relations (World Bank, 2004). These last three factors were explained as possible causes of distraction from work.

Barnes (2003) indicated how teachers are being encouraged in Ghana to facilitate local level development, which although could have positive impact on schooling, can also lead to teacher absenteeism and lateness.

In another study, Fobih, et al (1999) arrived unannounced in some 60 Ghanaian schools and found that about 85 per cent of teachers go to school late. Lateness ranged from five minutes up to one and a half hours. This meant teaching time was lost, teachers taught fewer school subjects (i.e. taught mainly English and Mathematics out of 8 subjects), and the shortening of the school day for pupils. Lateness and absenteeism affect completion of syllabi. When the syllabus is not completed, pupils find it difficult to understand content that is to be taught in the next class with its foundation in most cases is based on the previous class. This assertion buttresses Pryor and Ampiah's (2003) view that, most pupils do not do well academically in school because, they do not possess the understanding from previous work that is prerequisite for the syllabus of the Junior High Schools. to Bennell and Akyeampong (2007) pointed out absenteeism and lateness as contributing factors to nonperformance on the part of pupils and even teachers.

2.7.9 Teacher quality

Quality of teachers and commitment are key inputs in educational system to achieve better performance (Osei-Mensah, 2012). A teacher's knowledge of the subject matter coupled with textbooks, instructional time and other learning materials have great influence on learning at the basic school level. Acheampong (1993) mentioned that, a teacher who does not have both the academic and the professional teacher qualification would undoubtedly have a negative influence on the teaching and learning of his/her subject". According to Hedges (2002) many trained teachers are unwilling to accept postings to deprived communities in Ghana. As a result, there is a tendency for less qualified teachers to be employed in these communities, which affects their academic performances negatively.

Darling-Hammond (2000) sated that, teacher quality characteristics such as certification status and degrees in subject to be taught are very significant and positively correlated with subject outcomes in science and mathematics. Ingersoll (1999) found out that, 63 per cent of chemistry, physics, earth and space science instructors do not have certification in the subjects and this result in the poor performance of students in American Secondary schools. Also, Greenwald & Hedges (2002) asserted that, academic achievement should be positively correlated with teacher qualification. Additionally, Abuseji (2007) found teachers' qualification to be the second most potent causal effect on student's achievement in chemistry. Its direct and indirect effect accounted for 4.37 per cent, and 5.00 per cent of the total effect on students‟ achievement in chemistry in Lagos state, Nigeria.

Okoruwo (1999.pp 121) added that, teachers‟ teaching experience had significant effect on students‟ achievement in science. Also, Fettler (1999) investigated the relationship between measures of teacher's experience and student achievement in science and mathematics. The author came to a conclusion that, teaching experience as measured for years of service correlated positively with student test results.

In addition, to make science education effective, teachers need to transform how pupils think and assist them to make meaning and apply scientific knowledge as scientists do. This transformation can be done if and only if science teachers can instruct science lessons in a meaningful way (Wieman, 2008). It must further be noted that pupil's pre-representations, which are assembly of ideas and images they use to solve problems can be more or less accurate. It is expected of science teachers to discover and confront such representations to confirm or contradict them. This will help teachers to build new scientific knowledge in class (Kozan-Naumescu & Pasca, 2009). Hamushek (1992) reported that some teachers are intimidated by the challenge of learning new instructional strategies and therefore resist any change in their respective instructions. Wieman (2008) in his presentation revealed that, the issue with science education is for teachers to develop a mindset that their instruction should be deployed in a similar way with all the rigor and standard as scientists conduct scientific research. Consequently, science teachers are expected to create an environment conducive for pupils' active questioning and identification of issues and answers by employing appropriate instructional strategies (Dass & Yager, 2009).

Further in Africa the problem of teachers teaching at the JHS level in Sub-Saharan African villages is the inability of teachers to use SCIS instead of teacher-cantered ones (Pryor & Ampiah, 2003) and in San Francisco Bay Area, teachers in K- 5 schools taught science using basically lecture methods based on textbooks (Thomberg, 2009). The teacher-centered instruction is reported to have become necessary as most students in African villages find it difficult to make any meaningful verbal interactions in English Language (L_2) or even Ghanaian Language (L_1) for the case of Ghana with respect to topics in the curriculum.

The study of Pryor and Ampiah (2003) revealed that most teachers were cautions with language policy adopted by Ghanaian Basic Schools, where the medium of instruction for the lower primary is L_1. JHS teachers including science teachers were of the view that the use of L_1 affect students' performance as the transition is poor and most students are left in the state of confusion. This is because all materials except those in Ghanaian Language are written in L_2 and students found it difficult to understand exercises written in L_2.

Dass and Yager (2009) reported that the nature of science teaching in schools and colleges has changed over the last 50 years and there is therefore a need for new perspective of school science education. For teachers to meet the changing nature of school science and the changing notions of what desirable science education is, they are expected to undergo effective professional development that can address such changes. Thomberg (2009) identified staff development as what teachers need to transform science studies into an inquiry-driven project- based learning. This staff development should be structured in such a way that it will take regular forms. Kozan-Naumescu and Pasca (2009) found that teachers within the bracket of pre- university education are involved in continuous education. This places two main challenges at the door steps of such teachers. That is teachers are partly required to raise the level of scientific knowledge of their respective areas of teaching and to raise the level of psycho-educational and methodical preparations in their lessons with respect to current trends of education.

Fensham (2008) mentioned that, it is better to have less quality time of science learning to learning science aided by an under-equipped teacher. Fensham therefore recommended that members of Science Teacher Associations who are much experienced in the problems embedded in the teaching and learning of science should equip their colleagues who are under-equipped in order to offer the needed assistance to pupils. This is an indication that, even at higher platforms such as that of UNESCO, science educators and other interest groups appreciated that, science is bedeviled with some problems and if not identified and removed could still hinder the heights science education could attain in the 21 Century. This is because school science has been identified as tool that could help to delight societies and share in the scientific enterprise (Fensham, 2008).

Effective teaching embraces a variety of different aspects of teaching such as subject mastery, effective communication, lesson preparation and presentation, pacing the class to the students" level and taking into account individual differences, allowing students to practice and applying what they have learned, letting students know what is expected of them, and monitoring and evaluating performance so that students learn from their mistakes. Jacob and Lefgren (2006) found a positive correlation between effective teaching and academic achievement. Similarly, Adediwura and Tayo (2007) suggested that, effective teaching is a significant predictor of pupil's academic achievement and concludes that effective teaching produce pupils of higher academic quality.

2.7.10 Pupils characteristics

Several students' characteristics have generally been identified as influences to their academic performance. These include time with books and homework, attendance in school, students" attitude towards schooling, students" self-concept and motivation, health and nutritional status of students.

According to Engin-Demir (2009) regardless of intelligence, pupils who spend more time on assignments and homework are very important activities to improve their grades. The amount of time students invests in homework and other related activities have also been found to be strongly related to motivation. Butler (1987) found homework to be a correlate of academic performance. He stated that "homework bore a positive relationship with learning outcomes when it is relevant to learning objectives, assigned regularly in reasonable amounts, well explained, motivational and collected and reviewed during class time and used as an occasion for feedback to students". Homework and assignments are in reality an interaction between school and the home, and an essential ingredient of the educational process when measuring academic achievement.

Moreover, Stricker and Rock (1995) conducted an analysis by assessing the impact of the students" initial characteristics (gender, ethnicity, parental education, geographic region and age) and the academic performance. They established that the students" initial characteristics have a modest impact on their academic performance with parental education being the most significant. In addition, school attendance has a high correlation with individual academic achievement (Osei-Mensah, 2012).

The success of a student in school is predicated on regular school attendance. According to Welsh et al. (2000) poor attendance such as truancy or unexcused absence from school, cutting classes, tardiness, and leaving school without permission is seen as important in determining students' academic performance. Heady (2003) argued that, there is a negative relationship between student academic achievement and work during school hours. As Akabayashi and Psacharopoulos (1999) came up with the fact that, additional working hours decrease a child's reading and computational ability, whereas additional hours of school attendance increases their reading and computational ability. This implies that much as pupils require maximum time to study in the classroom, the issue of extra classes should be looked at to ensure quality and not quantity of academic exercise. From their findings, Ray and Lancaster (2003) concluded that, too much time spent at work had negative impact on educational variables with marginal impact weakening at higher levels of study hours. The researcher believed that, unbalanced demand of work and education places a physical and mental strain on students and often leads to poor academic performance.

Several researchers have investigated into the significant role of pupil's attitude toward learning with regard to their academic achievement. Pupils' attitude such as absenteeism, truancy, indiscipline, etc. can affect their performance. For instance, McLean (1997) distinguished between the attitudes of high and low achievers, the author found that, five attitudinal factors were significantly related to academic performance. Pupils' attitudes may not only directly affect academic achievement, but also may indirectly influence the effect of other factors as well. In another study, Abu-Hilal (2000) investigated into the effects of attitude on pupil's level of aspiration. Despite the difference between the findings of these two studies, the authors achieved consensus as regards to the significance of attitudes in predicting achievement. Hasan (20011) further complemented the results of earlier studies with the former proving that, the students' initial attitude towards school was significantly related to academic performance, while the latter found that attitudes predicted the students' basic approach to learning.

2.8 The Concept of Academic Performance and Achievement

2.8.1 Meaning of academic performance

According to William (2018), Often a time people misconstrue "academic performance" to be a person's GPA. However, several factors contribute to a student's academic success. He noted that, while some may not graduate top of their class, they may hold leadership positions in several student groups or score high on standardized tests.

Because academic achievement is defined by different indicators of educational success, it can be measured in different ways. Liem (2019) asserted that, Single studies and meta-analyses have demonstrated that the associations between academic achievement and its predictors such as intelligence, motivation, and personality differ depending on how academic achievement is measured. Thus, it is important to differentiate between the different indicators of academic achievement. Liem (2019) added that, the APA book on testing and assessment in school psychology and education, provides a thorough overview of the assessment of academic achievement. In the following, according to (Geisinger 2013) Grade point average (GPA) is one of the most frequently investigated variables in educational psychology and education. Even though it is a valid predictor of subsequent academic success, the meta analysis in (Kuncel, et al. 2005) demonstrated that, one has to be cautious of self-reported GPA. Grades measure student's performance in the classroom as rated by teachers and are thus influenced by the frame of reference effect. Meta-analysis in Kuncel, et al. (2001) showed that the graduate record examination even predicted academic success in a highly selective sample such as graduate students. Burton and Ramist (2001) found out that, grades were slightly better predictors of college success than standardized scholastic aptitude tests but that the combination of the two greatly increased the amount of variance that could be explained in college success. They added that, in some countries, educational degrees are a direct result of the grades one obtains during one's educational career, whereas in other countries, they are also influenced by standardized achievement tests if those are used as entrance tests for further education. The most comprehensive overview of the international comparability of educational degrees obtained in different countries is provided annually by the Organization for Economic Cooperation Development (OECD) in "Education at a Glance" The researcher is of the view that, academic performance is a quantitative outcome such as a pupil's score in a test or examination. In Benjamin's view, as stated in Anderson (2022) while academic achievement is a qualitative outcome obtained from different evaluation techniques such as stoichiometry, observation, rating scale and even tests and examinations. Academic performance is a quantitative outcome such as a pupil's score in a test or examination.

2.9 Formulae and IUPAC System of Naming Inorganic Compounds

Corwin (2017) introductory chemistry gave the classes and subclasses of inorganic compounds as follows; **IUPAC Rules-;** Names and Formulas of Inorganic Compounds

1. ionic – compound composed of ions, but overall neutral charge (compound typically contains a metal)
   A. binary ionic compound – two elements: metal cation and non-metal anion
   B. ternary ionic compound – three elements: metal cation and polyatomic anion
2. molecular – compound composed only of non-metals (NOT in ionic form)
   C. binary molecular compound – two elements: both non-metals
3. aqueous acid – solution of acidic compound in water (compound typically contains hydrogen)
   D. binary acid – aqueous solution of acid with two elements: hydrogen and non-metal
   E. ternary oxyacid – aqueous solution of acid with three elements: hydrogen, non-metal, and oxygen

Before naming ionic compounds (A. and B. above), it is necessary to know how to name monoatomic cations – typically metals. For H, for main-group metals (except Sn and Pb), and for the transition metals Ag, Zn, and C ($H^{+,}$ Li^{+}, Na^{+}, K+, $Mg^{2+,}$ $Ca^{2+,}$ $Sr^{2+,}$ $Ba^{2+,}$ Ag^{+}, $Zn^{2+,}$ $Cd^{2+,}$ $Al^{3+)}$ name as "element name" ion, Na+ is sodium ion, Zn^{2+} is zinc ion. For transition metals e.g. ($Cr^{3+,}$ $Mn^{2+,}$ $Fe^{2+,}$ $Fe^{3+,}$ $Co^{2+,}$ Co^{3+}, $Ni^{2+,}$ Cu^{+}, $Cu^{2+,}$ $Hg_2^{2+,}$ $Hg^{2+,}$ $Sn^{2+,}$ Sn^{4+}, $Pb^{2+,}$ $Pb^{4+)}$ except (Ag, Zn, and Cd) and for Sn and Pb *note that Hg+ exists in its diatomic form, Hg_2^{2+} name as "element name" (charge in roman numerals) ions, Co^{3+} is cobalt(III) ion. Monoatomic anions – typically non-metals. For non-metals name as "element stem "ide ion, example

Table 5: Names of Anions and their chemical symbols

Anion	Name	Anion	Name
Br -	bromide	N^{3-}	nitride ion
Cl^{-}	chloride ion	O^{2-}	oxide ion
F^{-}	fluoride ion	P^{3-}	phosphide ion
I^{-}	iodide ion	S^{2-}	sulfide ion

polyatomic ions – typically oxyanions, one or more elements combined with oxygen polyatomic cation – only one is needed to be known for this course NH_4^+, ammonium ion polyatomic anions – Examples. It is best to use flash cards to memorize some of the existing naming trends.

Table 6: Names of Anions and their chemical symbols

Anion	Name	Anion	Name
OH	hydroxide ion	ClO	hypochlorite ion
CN	cyanide ion	ClO^{2-}	chlorite ion
MnO_4	permanganate ion	ClO^{3-}	chlorate ion
CrO_4^{2-}	chromate ion	ClO_4^-	perchlorate ion
$Cr_2O_7^{2-}$	dichromate ion	NO_2^-	nitrite ion
$C_2H_3O_2^-$	acetate ion	NO_3^-	nitrate ion
PO_4^{3-}	phosphate ion	SO_3^{2-}	sulfite ion
CO_3^{2-}	carbonate ion	SO_4^{2-}	sulfate ion
HCO_{3-}	hydrogen carbonate ion	HSO_4^-	hydrogen sulfate ion

A. Binary ionic compound

From formula to name – cation named first, followed by anion (drop the words "ion" in compound name) NaCl is sodium chloride, ZnO is zinc. For metals where more than one type of cation is possible, the charge must first be determined Fe_2O_3, iron is $Fe^{3+,}$ therefore name is iron (III) oxide. From name to formula – determine charge on each ion from name, write formula with neutral charge cobalt (III) oxide; cation is $Co^{3+,}$ anion is O^{2-} , formula must be Co_2^{3-} to have neutral (zero) charge

B. Ternary ionic compound – same general rules as for binary ionic compound, but with polyatomic anion. From formula to name $KMnO_4$ is potassium permanganate, $BaCO_3$ is barium carbonate, Cu $(NO_2)^2$ is copper (II) nitrite.

From name to formula – be careful to put parentheses around entire anion if more than one is needed nickel(II) acetate; cation is $Ni^{2+,}$ anion is $C_2H_3O_2^-$ formula must be $Ni(C_2H_3O_2)_2$

C. Binary molecular compound – only non-metals (no ions) from formula to name – name first element followed by second element with -ide suffix, also number of atoms of each element are indicated by using Greek prefixes (mono-, di-, tri-, tetra-, penta-, hexa-, hepta-, octa-, nona-, deca-) for 1-10 atoms, respectively (mono- prefix is only used when necessary) IF_6 is iodine hexafluoride, Br_3O_8 is tribromine octaoxide from name to formula – based on above rule, also note the IUPAC order for writing elements in molecular compounds: C, P, N, H, S, I, Br, Cl, O, F dichlorine pentaoxide is Cl_2O_5, tetra phosphorus decasulfide is P_4S_{10}

D. Binary acid

From formula to name – name as hydro- "element stem"-ic acid HBr (aq) is hydro bromic acid from name to formula – based on above rule, the symbol (aq) must be included to indicate aqueous solution hydrofluoric acid is HF (aq)

E. Ternary oxyacid – also requires memorization of polyatomic anions!

from formula to name – name as either "polyatomic anion stem"-ic acid for polyatomic anions which end in -ate or "polyatomic anion stem"-ic acid for polyatomic anions which end in -ite in some cases, the polyatomic stem slightly varies – as follows for all names used for this class.

Table 7: Names of Acids and their chemical symbols

Acid	Name	Acid	Name
$HMnO_4$	permanganic acid	H_3PO_4 (aq)	phosphoric acid
H_2CrO_4 (aq)	chromic acid	HClO (aq)	hypochlorous acid
$H_2Cr_2O_7$ (aq)	dichromic acid	$HClO_2$ (aq)	chlorous acid
$HC_2H_3O_2$ (aq)	acetic acid	$HClO_3$ (aq)	chloric acid
H_2CO_3 (aq)	carbonic acid	$HClO_4$ (aq)	perchloric acid
H_2SO_3 (aq)	sulfurous acid	HNO_2 (aq)	nitrous acid
H_2SO_4 (aq)	sulfuric acid	HNO_3 (aq)	nitric acid

2.10 Studies on Chemical Reactions

Kotz & Treichel (2023) asserted that, the process in which one or more substances are converted to one or more different substances, is termed as Chemical Reaction. The authors further explained that, a chemical reaction rearranges the constituent atoms of the reactants to create different substances as products. They owe the credit to the fact that, chemical reaction is part of technology and indeed of life itself. Burning fuels, making glass and brewing are among many examples of activities incorporating chemical reactions that have been known and used for thousands of years. Chemical reactions abound in a vast array of complicated processes that occur in all living systems.

To them, chemical reactions must be distinguished from physical changes. Physical changes include changes of state, such as ice melting to water and water evaporating to vapour. If a physical change occurs, the physical properties of a substance will change, but its chemical identity will remain the same. No matter what its physical state, water (H_2O) is the same compound, with each molecule composed of two atoms of hydrogen and one atom of oxygen. However, if water, as ice, liquid, or vapour, encounters sodium metal (Na), the atoms will be redistributed to give the new substances molecular hydrogen (H_2) and sodium hydroxide (NaOH). By this, we know that a chemical change or reaction has occurred.

Laidler (1987) posited that, a description of a reaction mechanism must deal with the movement and speed of atoms and electrons. The detailed mechanism by which a chemical process occurs is referred to as the reaction path, or pathway. Laidler added that, the amount of work done in chemical kinetics has led to the conclusion that some chemical reactions go in a single step, these are known as elementary reactions. Other reactions go in more than one step and are said to be stepwise, composite, or complex. To the researcher, measurements of the rates of chemical reactions over a range of conditions can show whether a reaction proceeds by one or more steps. Laidler (1987) found out that, if a reaction is stepwise, kinetic measurements provide evidence for the mechanism of the individual elementary steps. Information about reaction mechanisms is also provided by certain non-kinetic studies, but little can be known about a mechanism until its kinetics has been investigated. Even then, some doubt must always remain about a reaction mechanism. An investigation, kinetic or otherwise, can disprove a mechanism but can never establish it with absolute certainty.

The author also worked on reaction rate and defined in terms of the rates with which the products are formed and the reactants (the reacting substances) are consumed.to her, for chemical systems it is usual to deal with the concentrations of substances, which is defined as the amount of substance per unit volume. The rate can then be defined as the concentration of a substance that is consumed or produced in unit time. Sometimes it is more convenient to express rates as numbers of molecules formed or consumed in unit time. The researcher is optimistic that the above up-to-date information gathered, provides the opportunity of giving an insight into the methods, measures and various other parameters adopted by others, which would lead to significant improvement of the research design.

2.11 Summary

Kivinen and Ristela (2003) cited Jean Piaget in their book. According to him, people construct knowledge and meaning from their experiences. For Dewey, learning is something we do together, in interaction with each other, rather than an abstract concept. These were some of the arguments under the constructivist theory, their work was basically limited to Dewey's pragmatic constructivism which discussed a lot about theoretical ways of acquiring knowledge and not the different activities that will ensure retention. For activity–based theory, Hee, (2005) presented object-orientedness, Internalization/externalization, Mediation and Development as the four major principles and even added monitoring of developmental stages which is very essential to this work. Again, his work lacked modeled activities for learners. In reviewing the conceptual learning theory of this study, Fletcher et al. (2019), study identified recognizing patterns in information, forming linkages with concepts, acquiring deeper understanding of concepts, developing personal relevance, and applying concepts to other situations. Information gathered from https://blog.teachmint.comindicated that, pupils who have conceptual understanding are more knowledgeable than those who only know theoretical facts and procedures. They grasp why a concept is significant and how it can be applied in various situations. Information is put into logical order that allows them to learn and understand new concepts by relating them to the concepts they already know. The researcher found this information very significant in her study.

Under conceptual Framework of this thesis, the following were reviewed. The concept of chemical equation, principles underlying balancing of chemical equations, existing methods of balancing chemical equations, the periodic table and the role it plays in the teaching of chemistry, challenges in studying balancing of chemical equations, factors affecting students' academic performance, formulae and IUPAC system of naming inorganic compounds and Studies on chemical reactions. Though existing methods of balancing chemical equation was reviewed, none of them looked at a combinations of practical activities to ensure better grasping and retention of the concept of balancing chemical equations, Nonetheless, the review of the individual methods gave the researcher an insight to her work.

CHAPTER THREE

METHODOLOGY

3.0 Overview

The chapter discussed research design, study area, population, sample size, sampling procedure, research instrument, scoring the instrument, validity, reliability, data collecting procedure, pre-intervention, intervention and post-intervention strategies.

3.1 Research Design

The study was an action research, designed to improve pupil's performance on how to balance chemical equations correctly using four (4) activities and a combination of three existing methods of teaching balancing of chemical equation namely: Inspection, Traditional and Algebraic, some manual and other related topics in the study of chemistry. In order to achieve this, the researcher designed her own module (refer to Appendix G) to facilitate her teaching. Pre-interventional strategies were also designed to help identify pupil's problems. Outcome of the pre-interventional strategies and the responses from pupils of the school through the use of questionnaires and interviews contributed to the design of intervention activities for the pupils. A post-intervention test was also administered to pupils after the intervention activities. This was to assess its impact on the teaching and learning of how to balance chemical equations in other to evaluate or to change, in order to improve pupil's performance. The researcher looked at a holistic approach to problem-solving, using pre and post intervention test, questionnaire and interview for collecting and analysing data.

3.2 Study Area

The Ablekuma South Sub-Metropolis is one out of the ten Sub-Metropolis of the Accra Metropolitan Assembly. The sub-metropolis has a total estimated population of two hundred and thirty-seven thousand five hundred and forty-three (257,543) and the inhabitants are predominately Ga speaking. The sub-metropolis consists of four communities namely the Chorkor Community, Korle-Bu Community, Korle Gonno Community and Mamprobi Community. The Mamprobi Community shares boundaries with Chorkor at the South, at the North by Lartebiokwashie. To the West is Dansoman and to the East is Korle Gonno. http://www.researchgate.net. The researcher used Socco H/H Basic which is one of the public schools in Mamprobi for the study because it is an average performing school and also very accessible to reach.

3.3 Population of the Study

Population is the target group for a study (Frankel & Wallen, 2003). According to the authors, it involves all the individuals (or objects) with certain specific characteristics. They further noted that, it is from the population that the researcher will deduce the results. In the view of Rubin and Babbie (2016), the population of a study is theoretically specified as the unit for individuals or objects about which information is collected and provides the basis for analysis. In this study, the target population was made up of JHS two (2) pupils in Socco H/H Basic School in the Mamprobi Community.

3.4 Sampling Procedure

The researcher was assigned a form two (2) class of 40 pupils. Purposive sampling was employed because it was an intact class and also the group that would enrich the study. According to Nikolopoulou (2022), purposive sampling refers to the selection of units "on purpose" because they have characteristics needed for the study. The author added that, it is a non-probability sampling and also known as judgmental sampling because it relies on the researcher's judgment. The researcher made a call to the head teacher and arranged for a meeting to conduct an interview and pre intervention test to the pupils. She then met with the head teacher, teachers and pupils on the scheduled date to explain to them the rationale behind the study. She also introduced herself to the pupils and asked them some questions to find out their difficulties in the study of balancing of chemical equation. Pre- intervention exercises were conducted. Supervision was done by the researcher with the help of the science teacher. The question papers were collected after an hour and marked with a marking scheme.

3.5 Sample Size

Sampling according to Kumar (1999) is the process whereby a small proportion or subgroup of the population is selected for scientific observation and analysis. Sample is a smaller proportion of a population selected for a study (Seidu, 2006). The sample for the study was made up of forty (40) JHS 2 pupils of Socco H/H Basic School within the Mamprobi community of the Greater Accra Region of Ghana. The sample was made up of twenty-two (22) girls and eighteen (18) boys.

3.6 Research Instruments

The instruments used for the study consisted of interview guides, questionnaires, pre-intervention tests and post-intervention tests. Thirty pre- intervention test items were administered to the class to help identify their difficulties in the balancing of chemical equations. This was followed by pupils responding to the interview items to voice out some of the difficulties they encountered in the pre- intervention test and how they could improve on their Performance. The intervention administered in this study employed the use of six (6) activities namely the recitation of the first twenty elements using the chemical symbols, drawing of the distributed electrons on the shells, writing out the electron configuration, going through the stick and hole activity, using the criss-cross (a pattern of intersecting straight lines or path) activity, combination of the three existing methods to write chemical formulae and using the table method to balance the chemical equation. This was to help the pupils to improve on their understanding of the concept. A questionnaire of ten items was also administered to find out the extent of pupil's knowledge of the principles underlying the concept. After the intervention, a set of forty post- intervention test questions in ten (10) sections with the same level of difficulty as the pre- intervention test was given to pupils to assess the effectiveness of the various activities used as the intervention strategy in teaching balancing of chemical equations. The post intervention questionnaire was administered to elicit their personal responses from the intervention exercise.

3.7 Scoring the Instrument (Pre and Post Intervention Test Items)

The instrument was scored with the help of these conceptual indicators in a written exercise.

- Identification of symbols of the elements
- The atomic structure
- Metals and non-metals
- Formula of binary compounds
- Equations of reactions involving elements to form compounds
- Providing products when reactants are given
- Balancing of chemical equation

3.8 Validity of the Main Instrument

Validity refers to how well a test measures what it is purported to some expects were employed to ascertain how best the test items meet the validity expectations in the face of the content. Necessary changes were made to improve upon the items in the test items to improve them.

3.9 Reliability of Instrument

Reliability is the degree to which an assessment tool produces stable and consistent results (Phalen & Wren, 2005). The researcher used same group of pupils for same test on different times. The stability of scores over time requires that all other things are equal. The researcher used test-retest reliability to assess the consistency and reproducibility of results obtained. The raw data gathered, was analysed using Cronbach's Alpha statistics to establish the reliability co-efficient of the pre and post-intervention items with the value of 0.75. The Cronbach's Alpha statistical instrument was developed by Lee Cronbach in 1951 to measure reliability or internal consistency. Higher Cronbach values indicate that response values for each participant across a set of questions are consistent. Cronbach's alpha provides the average of all possible split-half, rather than forcing the researcher to only select one for analysis (Taber, 2017).

3.10 Data Collection Procedure

Kelley et al. (2003), posited that, inspecting the research site and seeking for permission and consent are the most important ethical issues to adhere to when conducting a survey. They further suggested that, all information obtained should be used for the intended purpose. The researcher sort for permission and consent before the study was carried out. An application for permission to conduct a study in Socco H/H Basic School in the Ablekuma South Sub-Metropolis of the Greater Accra Region of Ghana was sent to the Ghana Education Service Directorate in the Accra Metropolis for permission to be granted in order to gain access to the school, pupils, teachers and other documents that would facilitate the study. The letter stated the objective and purpose of the study and the need for the participants to give their consent to and co-operate with the researcher. This was done as part of the ethical practice in research as suggested by Creswell (2003). He stated that, respecting the site where the research takes place and obtaining permission before entering a site is very paramount in research. The approval letters from the Metropolitan Education Directorate were used to solicit permission from the Head of school in order to administer the test and other activities that would be required in the research. The Head convened a short meeting with teachers to seek their maximum support. After meeting, the researcher gave a brief overview of the study, addressed concerns teachers have about the study, and solicited teachers consent to participate in the study. The researcher assured them of confidentiality in the execution of the research. A day was set to administer oral questions to the two teachers in order to aid the researcher to ascertain the problems of the pupils in balancing chemical equations. All the teachers responded to the items satisfactorily. After the teachers have finished responding to the items, they helped in the administration of pre and post- test.

3.11 Intervention Strategies

3.11.1 Pre-intervention activities

The following activities were carried out to help identify the problems associated with the teaching and learning of balancing of chemical equations in JHS two (2) in Socco H/H Basic School. Thirty (30) pre-test items in Ten (10) sections were given to pupils by the researcher to respond within an hour (60 minutes). The test items were scored over thirty (30) marks. This was conducted to expose the difficulties of the pupils in writing and balancing of chemical equations. The following are samples of pre-test items. The full test and the responses to the test are found in Appendix B.

Table 8: A Table of Elements and their Symbols

i. Provide the Chemical Symbols of the Following Elements

No.	Elements	Symbols
1	Chlorine	
2	Calcium	
3	Boron	
4	Hydrogen	
5	Nitrogen	

ii. Draw the atomic structure of the following elements

Hydrogen

Sodium

Carbon

iii. State the electron configuration of the following elements

Chlorine

Neon

Magnesium

3.11.2 Intervention stage

Intervention is the discrete action designed to improve the system but cannot predict exactly how things were going to turn out. (www.onecechote.com2006/05). According to Halse (2008), intervention is a goal- oriented interfering in a course of events to promote a preferred state. An intervention design was drawn up to address the identified problems that pupils face in balancing of chemical equations and its related topics. The intervention lasted for five (5) weeks, the researcher was assigned double periods in a week as specified on the time table and each period lasted 30 minutes. The intervention strategies included:

1. identifying symbols of elements and their corresponding atomic numbers using mnemonics.
2. going through with pupils on how to draw the structure of an atom and determining the electron configuration of elements.
3. classifying elements as metals and non-metals.
4. writing the formula of binary compounds
5. predicting reactants when products of a reaction are given.
6. balancing chemical equations involving binary and complex compounds using the table method.

Week One - Lesson One

Subject: Integrated Science

Class: JHS 2

Average age: 13 years

Strad: Elements Compounds and Mixtures

Sub Strand: Identification of symbols of elements and its atomic structures using mnemonics.

Duration: 60 minutes

Indicators: By the end of the lesson, the pupil will be able to

- identify and write the symbols of the first twenty elements.
- draw the atomic structures of the elements.

Resources: A chart of the first twenty elements.

Entry Behaviour: Pupils are familiar with alphabets.

Stater: Teacher writes some alphabets on chalkboard and ask pupils to mention them.

Phase One

The researcher hangs a chart of the first twenty elements on the chalkboard and asked pupils to repeat after her. She then used mnemonics to guide pupils to write the symbols of the first twenty elements. Pupils were made to know that most elements have the first letter or first two letters of their names as their symbols but elements like sodium (Na) and potassium (K) have symbols different from their names. Their symbols are derived from their Latin names. Sodium in Latin is called Natrium and Potassium is Kalium, hence, the symbols for Sodium and Potassium are Na and K respectively as indicated in Table 9.

Table 9: Names and Chemical Symbols of the First 20 Elements in the Periodic Table

Atomic Number	Elements	Mnemonics	Chemical Symbols
1	HYDROGEN	HELLO	H
2	HELIUM	HELENA	He
3	LITHIUM	LISTEN TO	Li
4	BERYLLIUM	B	Be
5	BORON	B	B
6	CARBON	C	C
7	NITROGEN	NEWS	N
8	OXYGEN	ON	O
9	FLOURINE	FRIDAY	F
10	NEON	NIGHT	Ne
11	SODIUM	SOME	Na
12	MAGNESIUM	MINISTERS	Mg
13	ALUMINIUM	ARE	Al
14	SILICON	SELLING	Si
15	PHOSPHORUS	PITO	P
16	SULPHUR	SO	S
17	CHLORINE	CLIMB	Cl
18	ARGON	ARABA’S	Ar
19	POTASSIUM	KULA	K
20	CALCIUM	CARTER	Ca

Phase Two

The researcher guided the pupils to draw the atomic structures of some elements. She made them aware of the fact that, the atomic structure contains shells and the shells have their names and the number of electrons they can carry. The first shell, K-shell takes only two (2) electrons. The second shell, L-shell takes a maximum of eighteen (18) electrons. The M-shell also takes eight (8) electrons. The researcher further stated that, the position of the element determines their corresponding atomic number. The atomic number represents the number of electrons in the atom of the element. She quizzed pupils on the atomic numbers of nitrogen, calcium, oxygen, Boron, and Neon

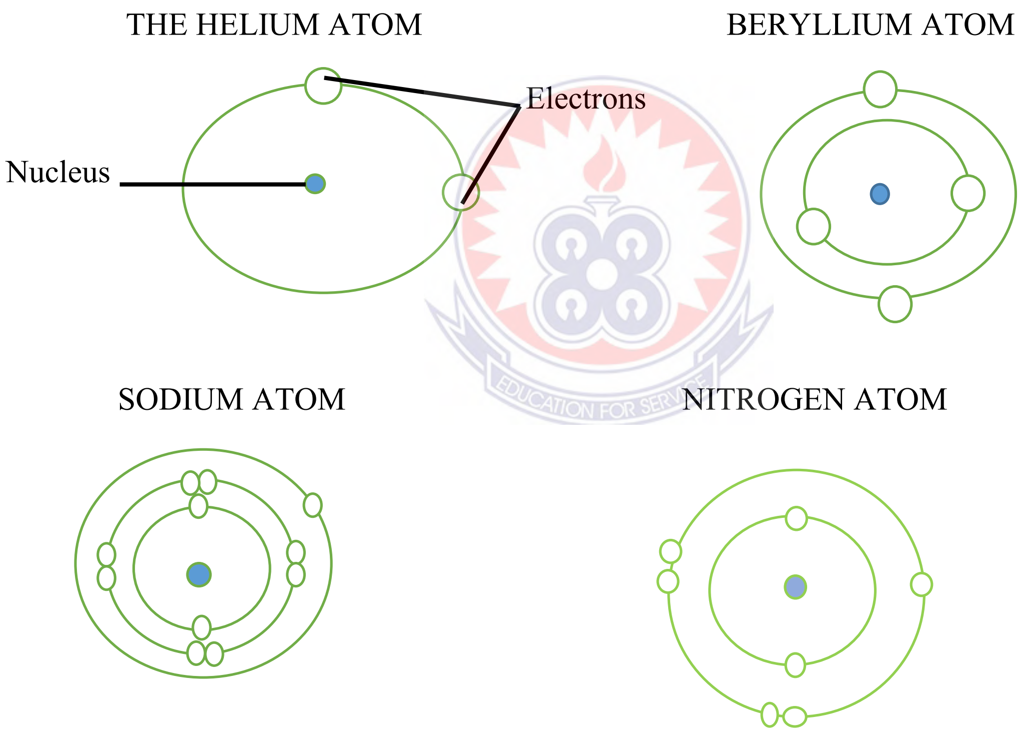


Figure 2: The atomic structures of some elements

Conclusion

In summary, the researcher asked the pupils to always learn to place elements at their correct positions as it will lead them to easily determine their atomic numbers. She asked pupils to:

1. Write the chemical symbols of each of the following elements.
   a. Nitrogen
   b. Calcium
   c. Oxygen
   d. Potassium
   e. Sodium

2. Draw the atomic structure of
   a. Nitrogen
   b. Calcium
   c. Oxygen
   d. Potassium

Week Two- Lesson Two

Subject: Integrated Science

Class: JHS 2

Average Age: 13years

Strand: Elements, Compounds and Mixtures

Sub Strand: Electron Configuration

Duration: 60 minutes

Resources: A chart showing the electron configuration of the first twenty elements.

Indicator: By the end of the lesson, the pupil will be able to:

1. write the electron configuration of elements.
2. determine valences of atoms from their electron configurations.
3. classify elements as metals and non-metals.

Entry Behaviour: the Pupils have been introduced to how to draw the structure of atoms of different elements

Stater: The researcher called some pupils to the chalkboard to draw the atomic structure of Carbon, Sulphur and Argon.

Phase One

The researcher guided pupils to define the electron configuration as the distribution of the electrons of atoms on the atomic shells. The researcher developed a chart showing the electron configuration of some elements with pupils.

With the previous knowledge of the distribution of electrons in the shells. The researcher introduced pupils to the general formula for determining the maximum number of electrons each shell can accommodate as in $2n^2$ where n is the assigned number to a shell. The first shell also called the K shell has a value of n = 1. The second shell has n = 2. The third shell M shell has n=3 and the forth shell N has a value of n=4 According to the JHS Integrated Science Syllabus, pupils must learn the first twenty elements on the periodic table. The researcher therefore guided pupils to write the electron configuration of the first twenty elements.

1. H- 1
2. He- 2
3. Li- 2,1
4. Be- 2,2
5. B- 2,3
6. C- 2,4
7. N- 2,5
8. O- 2,6
9. F- 2,7
10. Ne- 2,8
11. Na- 2,8,1
12. Mg- 2,8,2
13. Al- 2,8,3
14. Si- 2,8,4
15. P- 2,8,5
16. S- 2,8,6
17. Cl- 2,8,7
18. Ar- 2,8,8
19. K- 2,8,9
20. Ca- 2,8,8,2

Phase Two

The researcher introduced pupils to how to determine the valences of elements from the electron configuration. She explained to pupils that, some elements fill their outermost shells and they are known as noble, rare or inert gases. Therefore, elements would either loss or gain electrons to attain the noble gas configuration. The number of electrons lost or gained is therefore the valency of the element. The researcher together with pupils developed the table of elements showing their symbols, electron configuration and their valences as shown in table 10.

Table 10: Valences of Elements from their Electron Configurations

Atomic No.	Element	Symbol	Electron Configuration	Valency
2	Helium	He	2	0
13	Aluminum	Al	2,8,3	3
9	Fluorine	F	2,7	1
17	Chlorine	Cl	2,8,7	1
8	Oxygen	O	2,6	2
5	Boron	B	2,3	3

Phase Three

The researcher explained to pupils that all the elements having 1 to 3 electrons are classified as metals while the elements with 5, 6, and 7 in the outermost shells within the first twenty elements are non-meals.

In groups of five, pupils were made to classify all the twenty elements as metals and non-metals as indicated in table 11.

Table 11: Classifying the First Twenty Elements as Metals and Non-metals

Metals	Non-metals
Li	N
Be	O
B	F
Na	P
Mg	S
Al	Cl
K	
Ca	

Conclusion

In summary, the researcher asked pupils questions and write the responses on the chalkboard in a form of notes for pupils to copy.

Week Three – Lesson Three

Subject: Integrated Science

Class: JHS 2

Average Age: 13years

Strand: Chemical Compounds

Sub Strand: Predicting reactants when products are given

Duration: 60minutes

Indicator: By the end of the lesson, the pupil will be able to;

1. Write formula of binary compounds
2. Predict reactants when products of a reactions are given.

Resources: Sample of water

Entry Behaviour: Pupils have been taught metals and non-metals.

Stater: The researcher asks pupils to differentiate between a metal and a non- metal.

Phase One

The researcher in a discussion lesson, presented to pupils the following compounds for them to identify the constituent elements.

1. FeS
2. NaCl
3. H_2O
4. MgO

Products from reactants were explained to be the species formed from chemical reactions. During a chemical reaction, reactants are transformed into products. Example: hydrated iron (ii) oxide is the constituent of rusting. The reactants of rust are iron and oxygen in the presence of water. $4Fe + 3O_{2(g)}$ $2Fe_2O_{3(s)}$ $\longrightarrow$

Phase Two

The researcher used the sticks and holes activity to introduce pupils to how to write the formula of chemical compounds. She explained that, atoms of elements with 1, 2, and 3 electrons in their outermost shell will be represented as atoms with 1, 2, and 3 sticks respectively. On the other hand, atoms of elements with 5,6 and 7 electrons in their outermost shell will be represented as atoms with 3, 2 and 1 holes respectively. The activity demanded that, all sticks be used and all holes be filled. This is represented in tables 12 and 13

Table 12: Number of Electrons and Corresponding Number of Sticks of Elements

Elements	No of Electrons in outermost Shells	No of Sticks
1 lithium	1	1
2 Boron	3	3
3 Sodium	1	1
4 Beryllium	2	2
5 calcium	2	2

Table 13: Number of Electrons and Corresponding Number Holes of Elements

Elements	No of Electrons in outermost Shell	No of Holes
1 Phosphorus	5	3
2 Oxygen	6	2
3 Fluorine	7	1
4 Sulphur	6	2
5 Nitrogen	5	3

The researcher also leads pupils to explain metals as elements whose atoms readily give out electron(s) in a chemical reaction and non-metals as elements whose atoms accept electron(s) in a chemical reaction. Pupils were made to understand that compounds are formed between metals and non-metals.

The formula of the compound of sodium and oxygen is generated as follows:

Figure 3: The first step of the formation of compound from sodium and oxygen

Oxygen has two holes and so, how many sticks of Sodium will be able to fill these holes bearing in mind all holes must be filled and all sticks must be used.

Therefore, two sticks from two atoms of sodium are used to fill the two holes of one atom of oxygen.

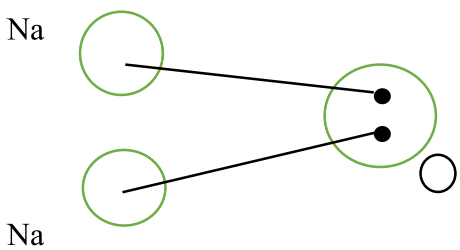


Figure 4: The second step of the formation of compound from sodium and oxygen

Therefore, the formula of the compound formed between sodium and oxygen is Na_2O.

The compound Aluminium and oxygen was also determined as follows:

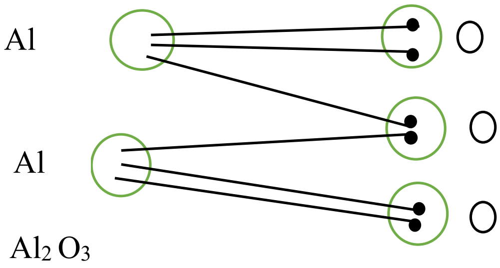
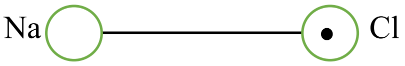


Figure 5: The third step of the formation of compound from sodium and oxygen

Two Aluminums are required to fill the six holes of three oxygen.

The compound between Sodium and Chlorine was generated as



One hole is to one stick NaCl.

Figure 6: A diagram showing the of formation of compound from sodium and chlorine

Conclusion

The researcher asked pupils to write the following chemical formulas of compounds to end the lesson.

A reaction between the following.

i. Magnesium and Oxygen

ii. Aluminum and Chlorine

iii. Hydrogen and Oxygen.

Week Four- Lesson Four

Subject: Integrated Science

Class: JHS 2

Average Age: 13 years

Strand: Chemical compounds

Sub-Strand: Writing Chemical Formula of compounds using valences

Duration: 60 Minutes

Indicator: By the end of the lesson, the pupil will be able to

- Write chemical formulae of compounds from word equations
- Write chemical formulae of compounds using valences

Resources: Blackboard illustrations.

Entry Behaviour: Pupils can identify symbols of elements

Stater: The researcher writes names of elements on chalkboard and asks pupils to write their symbols in their books.

Phase One

The researcher leads pupils to write chemical compounds from word equations

Examples: Aluminum and Oxygen

Sodium and Oxygen

Hydrogen and Oxygen

Hydrogen and Sulphur

Phase Two

The researcher assisted the pupil using the criss cross method to write chemical formulae using valences as follows:

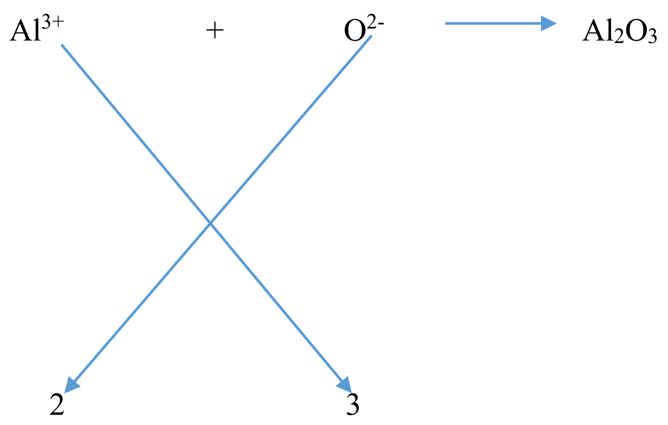


Figure 7: A diagram showing the formation of compound from Aluminium and Oxygen

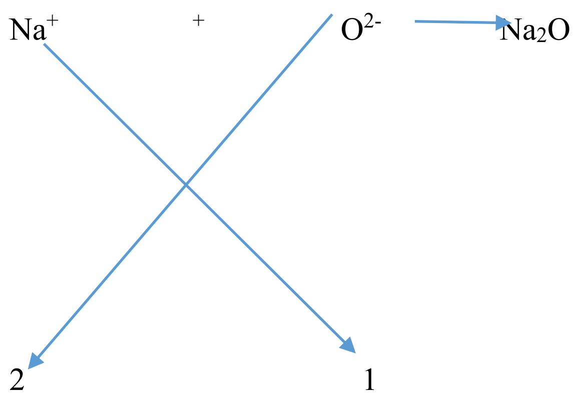


Figure 8: A diagram showing the formation of compound from sodium and Oxygen

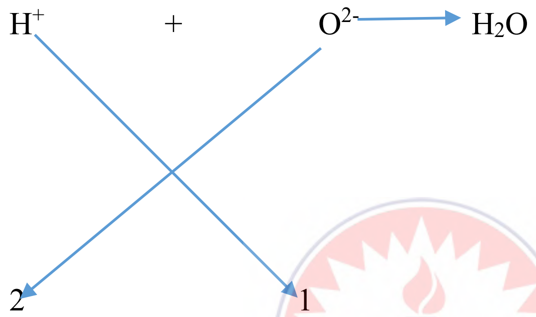


Figure 9: A diagram showing the formation of compound from hydrogen and Oxygen

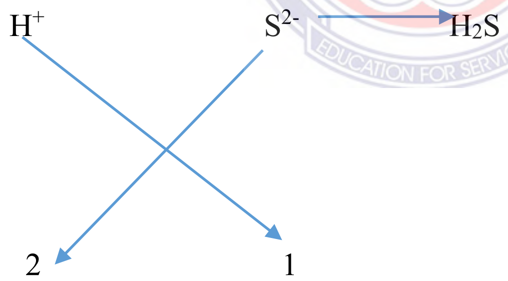


Figure 10: A diagram showing the formation of compound from hydrogen and Sulphide

Conclusion

The researcher concluded the lesson by writing the following compounds for pupils to write its chemical formula using their valences

1. Lead oxide
2. Carbon dioxide

3. Iron (iii) oxide
4. Aluminum chloride

Week Five- Lesson Five

Subject: Integrated Science

Class: JHS 2

Average Age: 13Years

Strand: Chemical Compounds

Sub Strand: Balancing of Chemical Equations

Duration: 60minutes

Indicator: By the end of the lesson, the pupils will be able to:

- Outline the steps involved in balancing chemical equations.
- Balance chemical equations of binary and complex compounds using the table method.

Resources: A chart showing the table method of balancing chemical equation.

Entry Behaviour: Pupils have been taught how to write chemical formula of compounds.

Stater: The researcher asked the pupils to write the steps in writing and balancing chemical equations as follows.

Phase One

The researcher then leads the pupils to explain the table activity as having the reactants and products on both sides of the equation in a table form and making sure both sides are balanced.

Phase Two

The researcher wrote some word equations on chalkboard and ask pupils to write its chemical equations.

Example: 1. what will be the product of combining 2 atoms of hydrogen and 2 atoms of oxygen?

Expected Answer: $H_2 + O_2 \longrightarrow H_2O$

2 Write the Chemical formula of the compound formed when an atom of Nitrogen combines with atoms of Hydrogen.

Expected Answer: $N_2 + H_2$ ……… NH_3

Phase Three

The researcher led pupils to balance chemical equations using table method.

Example 1:

Table 14: Balancing Chemical Equations of Hydrogen and Oxygen using the Table Method

$$H_2 + O_2 \longrightarrow H_2O$$

LHS	RHS
H=2	H=2
O=2	O=1

The oxygen is not balanced so we multiply it by 2 so that oxygen will be balanced.

$$H_2 + O_2 \longrightarrow 2H_2O.$$

Hydrogen (H_2) on the other side is not balanced as compared to the hydrogen on the other side. We can therefore balance H_2 by placing 2 in front of it.

Hence the balanced equation is $2H_2 + O \longrightarrow 2H_2O$.

Let's check to see whether all the atoms are balanced on both sides of the equation.

Table 15: The Balanced Chemical Equations of Hydrogen and Oxygen Using the Table Method

$$2H_2 + O_2 \longrightarrow 2H_2O$$

LHS	RHS
H=4	H=4
O=2	O=2

Table 16: The First Step of Balancing Chemical Equations of Hydrogen and Nitrogen Using the Table Method

Example 2: $N_2 + H_2 \longrightarrow NH_3$

LHS	RHS
N-2	N-1
H-2	H-3

The nitrogen at the right hand side is not balanced so let's multiply the NH_3 by 2 as.

Table 17: The Second Step of Balancing Chemical Equations of Hydrogen and Nitrogen Using the Table Method

$$N_2 + H_2 \longrightarrow 2NH_3.$$

H_2 at the left hand side is not balanced as compared to H on the right hand side. So let's multiply H_2 by 3 as.

Table 18: The Third Step of Balancing Chemical Equations of Hydrogen and Nitrogen Using the Table Method

$$N_2 + 3H_2 \longrightarrow 2NH_3.$$

Let's check to see whether all the atoms are balanced on both sides of the equation.

Table 19: The Final Balanced Step of Balancing Chemical Equations of Hydrogen Nitrogen Using the Table Method

$$N_2 + 3H_2 \longrightarrow 2NH_3.$$

LHS	RHS
N-2	N-2
H-6	H-6

The equation is therefore balanced.

3.12 Post Intervention Activity

The researcher gave out the post intervention questions for pupils to answer. With the help of the science teachers, the test was supervised. After an hour, the scripts were collected. Pupils together with the researcher answered all the questions correctly. The scripts were marked with a marking scheme. Again, questionnaires were shared to pupils to elicit their responses on their perception of the activity-based method after the intervention.

3.13 Data Analysis

Data collected from pre- and post-intervention activities were analyzed using: simple percentages with bar charts representations. Calculations were performed using statistical software, SPSS. The data collected from both pre and post-test intervention activities were examined for consistency by reading through the scores obtained by the students. The results were then analysed by the use of descriptive statistics. The results of the pre-test revealed to the researcher the weakness of the learners and that of the post test showed a great improvement of the concept based on the intervention. This showed a great impact and significance in the use of the intervention

3.14 Ethical Consideration

Ethics are the norms or standards for conduct that distinguish between right and wrong. They help to determine the difference between acceptable and an unacceptable behaviour (Resink, 2020). Major ethical issues in conducting research are: informed consent, respect for anonymity, confidentiality and respect for privacy. These are very important in research since they guard against the fabrication or falsification of data and therefore, promote the pursuit of knowledge and truth which is the primary goal of research. Based on the above enumerated important issues, consent for the conduct of the study was sought from the metro education directorate through to the Head teacher of the Basic school within the metro to participate in the research. A letter of introduction was also obtained from the Head of Department of Science, University of Education, Winneba to enable the researcher seek consent for the conduct of the study and to introduce herself to the participants in the study and solicit their involvement during data collection. Participants were assured of the necessary confidentiality as Cohen et al (2007), stated that, the right to privacy means a person has the right not to respond to questions from interviews, not to have their home intruded into, not to answer telephone calls or emails and to engage in private behaviour in their own private place without fear of being observed. Based on this, participants were assured of their privacy and respect at any point of the study.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.0 Overview

The chapter focuses on the presentation of findings and the analysed data based on the intervention strategies employed by the researcher to improve the pupils' conceptual understanding of balancing chemical equations in accordance to the research questions in Chapter One.

4.1 Presentation of the Result by Research Dimensions

4.1.1 Analysis of data with respect to the research questions

Research Question 1: What are the pupil's conceptual difficulties in balancing chemical equations?

This research question sought to elicit the pupils' conceptual difficulties in balancing chemical equations through an interview guide and the pre-test excerpts. A table of interview responses analysis is shown, followed by a descriptive data analysis. The frequency of pupils who answered a particular question was taken and then converted into percentages as indicated in table 20

Table 20: Pupils Responses to Interview on their Prior Conceptual Difficulties of Balancing Chemical Equations

S/N	Interview Questions	No of Respondents= 40							
		Uncertain		To some Extent		Yes		No	
		Freq.	Perc.	Freq.	Perc.	Freq.	Perc	Freq.	Perc.
1	Balancing of chemical equation lessons are interesting	2	(5)	2	(5)	28	(70)	8	(20)
2	Can you write the first twenty elements in their correct order and assign their electron configuration			10	(25)	10	(25)	20	(50)
3	Do you think Balancing of chemical equation is difficult.?			8	(20)	25	(62.5)	7	(17.5)
4	Are you able to assign number of protons and valences to elements?			10	(25)	2	(5)	28	(70)
5	Are you able to identify metals and non-metals?			8	(20)	6	(15)	26	(65)
6	Do you know which element is placed first when combining elements to form compounds?					7	(17.5)	33	(82.5)

From table 20, 5% of the respondents were uncertain about how interesting balancing of chemical equation is, 5% of them said, to some extent, balancing of chemical equation is interesting. Again, 7o% of them perceived balancing of chemical equation to be interesting and 20% of the respondents did not perceive balancing of chemical equation as an interesting concept. Approximately 25% of the respondents know element, their positions and configuration to some extent. Only 25% of them responded yes to the fact that, they know elements, their positions and configuration. Fifty percent (50%) of the respondents said they do not know elements, their positions and configuration. sixty-two point five (62.5%) of the pupils said balancing chemical equations is difficult. While 20% said to some extent, Meanwhile, 17.5% responded that, it is not difficult to balance chemical equations. Approximately 70% of respondents responded that, they were unable to assign protons and valences to elements, only 2% responded yes to that effect. Twenty (25%) of respondent could do that to some extent. In addition, 65% of respondent said they could not identify metals and non-metals. Approximately 20% of respondents identify metals and non-metals to some extent. Only 15% of them said they are able to identify metals and non-metals. Lastly, 82.5% respondent responded no to whether they know which element is placed first when combining elements to form compounds. Only 33% of the respondents responded yes to same question. Ali (2012), was far from wrong when he said that, students seemed confused despite teacher's good efforts to communicate the concept using a variety of simple examples and explanations. This indicates that, unless student's grasp initial basic concepts in learning, they may not be able to cope with the advanced level knowledge. This underscores the critical importance of pupils learning basic science concepts in the early stages with understanding and goes to explain why 45% of the respondents responded that, the concept of balancing of chemical equation is confusing. To Ali, the recognition of the teacher's vital facilitative role in in-depth student learning necessitates the use of effective equipment by teachers with professional competencies (knowledge, skills, and disposition). The findings from the respondents are in support of the literature on the challenges in studying balancing of chemical equations.

4.1.2 Discussion of results in relation to research question 1

The responses of the respondents during the interview, showed that, pupils had poor understanding if any about how to balance chemical equations. Before the intervention, pupils could not write chemical formula of compounds neither could they place coefficients in front of chemical entities. Most pupils could not balance simple binary chemical equations such as H_2+ N_2-----NH_3. Anderson (1986) asserts that, many students' often fail to visualize chemical reactions as dynamic processes in which particles and molecules react to produce new particles and molecules. The pupils of Socco H/H JHS 2, also faced similar difficulties. They found it difficult to assign correct symbols to the elements. They were not able to draw the atomic structure of elements as well as electron configuration which will enable them to come up with the valency of the atom. However, the trend changed after the implementation of intervention strategies. Pupils could now write the symbols of elements, draw the structure of the atom and from the structure, determine the electron configuration and consequently the valences of elements.

Research Question 2: To what extent do the pupils know the principles underlying the balancing of chemical equations?

This question was set to find out if the respondents were abreast with the principles of the concept using questionnaire as a tool. A questionnaire analysis is indicated in table 10 to depict the data which is followed by a descriptive analysis of the it. A graph showing the data representation of the responses of table 21 is shown.

Table 21: Pupils Responses to Questionnaire on Respondents' Prior Knowledge of Principles underlying Balancing of Chemical Equation

SN	Premise	Number of Respondents=40				
		SAF (%)	AF (%)	UF (%)	DF (%)	SDF (%)
1	The reactants taking part in a chemical reaction are written in symbols	2(5)	8(20)	8(20)	20(50)	2(5)
2	Reactants are ingredient in a chemical reaction	5(12.5)	4(10)	15(37.5)	12(30)	4(10)
3	Products are produced from the reaction of substances.	3(7.5)	7(17.5)	10(25)	15(37.5	5(12.5)
4	The reactants and products have the same number of atoms of different elements in a balanced equation	4(10)	13(32.5	6(15)	10(25)	7(17.5)
5	The reactants and products have equal masses of different elements in a balanced chemical equation.	8(20)	8(20)	12(30)	5(12.5)	7(17.5)
6	Identifying the number of elements in a chemical equation aids balancing chemical equation effectively	6(15)	4(10)	8(20)	12(30)	10(25)
7	It is very important to ensure that there is the same number and type of atoms on both sides of a chemical equation.	7(17.5)	10(25)	7(17.5)	10(25)	6(15)
8	When combining metals and non- metals, to form compounds, the metals must be placed first.	10(25)	6(15)	10(25)	8(20)	6(15)
9	It is always important to ensure that the number of atoms of each kind on both sides of the equation is equal	10(25)	8(20)	12(30)	7(17.5)	3(7.5)
10	The shells of the atom take the same number of electrons	8(20)	10(25)	13(32.5)	4(10)	5(12.5)

Key: SAF = Strongly Agree Frequency, A= Agree Frequency, NF =Neutral Frequency, DF= Disagree Frequency, SDF= Strongly Disagree Frequency. Source: Field data, 2023

From table 21, only 25% of the pupils agreed that, the reactants taking part in a reaction are written in symbols. 20% stayed neutral and approximately 55% disagreed to the above assertion.35% of the pupils were neutral to the fact that, reactants are the ingredients in chemical reactions. Approximately 40% of the respondents disagreed and only 30.5% agreed to the assertion. Fifty percent (50%) of the respondents disagreed to the assertion that, products are produced from the reaction of substances. Ten percent (10%) stayed neutral and only 25% agreed to the assertion. Fifteen (15%) were neutral to the fact that, reactants and products have the same number of atoms of different elements in a balanced equation. Approximately 42.5% disagreed to the assertion and 42.5% agreed to it. Thirty percent (30%) of the respondents disagreed that, reactants and products have equal masses of different elements in a balanced chemical equation.30% were neutral to that and 40% agreed to the assertion. Twenty percent (20%) of the respondents stayed neutral to the fact that, identifying the number of elements in a chemical equation aids balancing chemical equation effectively.55% and 25% disagreed and agreed respectively to the assertion. Thirty-two point five percent (32.5%) agreed to the fact that, it is very important to ensure that there is the same number and type of atoms on both sides of a chemical equation. Seventeen percent (17%) stayed neutral and 40% disagreed to it. Thirty-five (35%) disagreed to the assertion that, metals are placed first when combining metals and non-metals to form compounds, 25% were neutral and 40% agreed to the assertion. 45% of respondents agreed to the fact that, it is always important to ensure that the number of atoms of each kind on both sides of the equation is equal.30% were neutral to that, and 25% disagreed to the assertion. Forty-five (45%) of the respondents agreed to the false assertion that, the shells of an atom take the same number of electrons. Only 22.5% opposed that and 32.5% were neutral to the assertion. The data showed above indicates that, the respondent's prior knowledge of the principles underlying the concept before the intervention was abysmal. According to Parth (2022). The number of molecules involved in a process is known as the stoichiometric coefficient or stoichiometric number. A critical look at a balanced reaction indicates that, both sides of the equation have the same number of elements. The number in front of atoms, molecules, or ions is known as the stoichiometric coefficient. Parth indicated that, fractions and whole numbers can both be used as stoichiometric coefficients. The factors essentially assist us in determining the mole ratio between reactants and products. Let's observe the percentile frequencies of respondents from table 21.

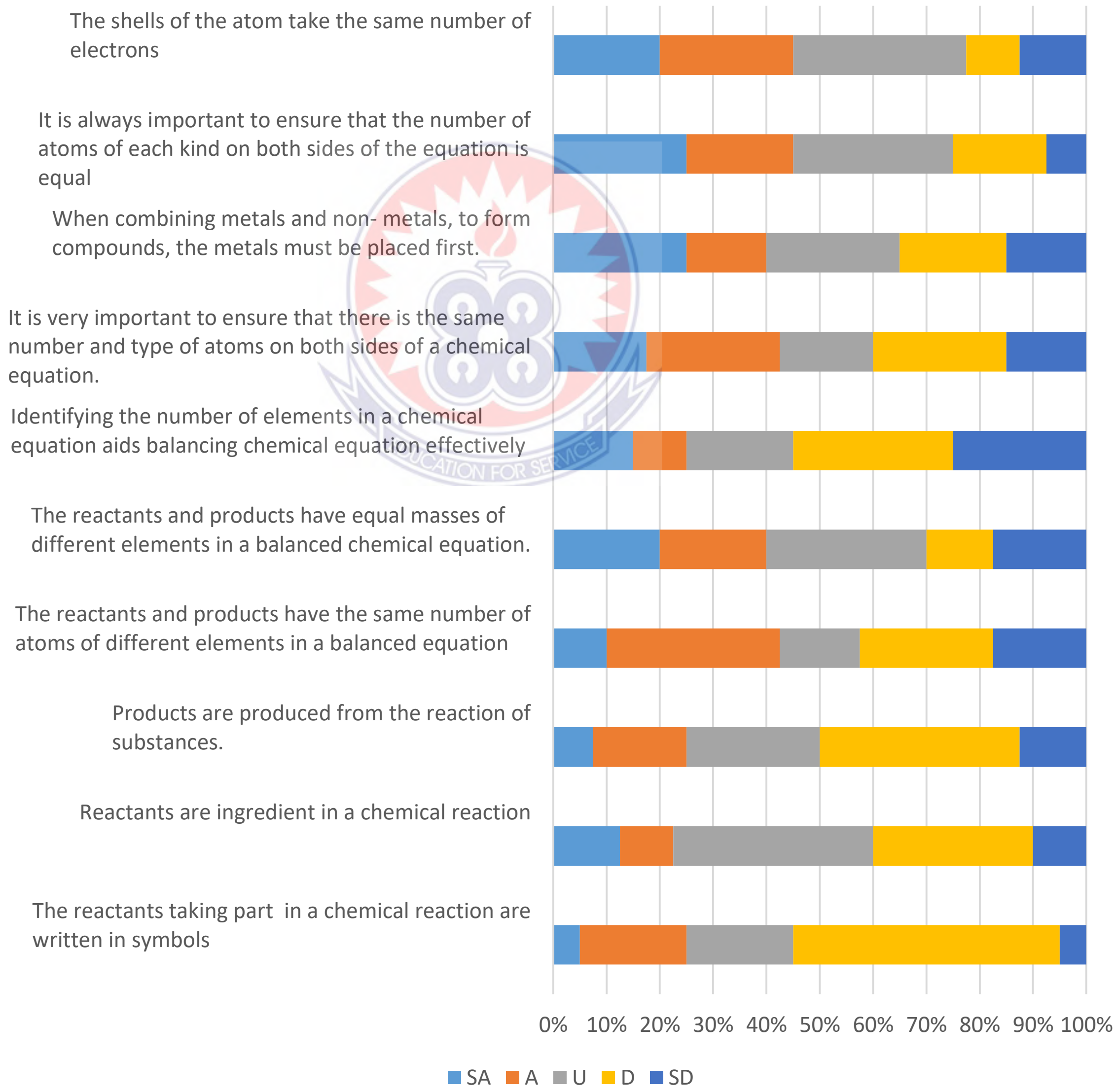


Figure 11: A graph showing the data representation of questionnaire response of Table 21

4.1.3 Discussion of results in relation to research question 2

From the learner's responses of the questionnaire administered, it was observed that, pupils of Socco H/H JHS 2 lacked the idea of the principles in balancing chemical equation before the intervention. These principles are basically the steps pupils have to go through in writing a balanced chemical equation. Pupils were taught the steps during the intervention stages. The date from the questionnaire they filled after the intervention, showed a great improvement and a better understanding of the concept.

Research Question 3: What are the effects of the activity–based method of teaching on the pupil's performance in balancing chemical equations?

This question assessed the effectiveness of activity based method on pupil's achievement in balancing chemical equations as shown in Tables 22 and 23

Table 22: Scores of Pupils Pre- Intervention Test

Marks(x)	Frequency (f)	Class midpoint (x)	Fx	Percentages (%)
0-5	18	9	162	45
6-10	20	10	200	50
11-15	1	0,5	0.5	2.5
16-25	1	0,5	0,5	2.5
21-25	0	0	0	0
26-30	0	0	0	0
	$\sum(f)$=40		$\sum(fx)$=363	$\sum(\%)$=100

Mean $(x) = \frac{\varepsilon f x}{\varepsilon(f)} = \frac{363}{40} = 9.08$

Table 23: Performance of Pupils Post- Intervention Test

Marks(x)	Frequency	Class midpoint (x)	Fx	Percentage (%)
0-5	0	2.5	0.0	0
6-10	0	8	0.0	0
11-15	4	13	52	10
16-20	6	18	108	15
21-25	5	23	115	12.5
26-30	8	28	224	20
31-35	9	33	264	20
36-40	9	76	144	22.5
	$\sum(f)$=40		$\sum(fx)$=907	$\sum(\%)$=100

Mean $(x) = \frac{\sum fx}{\sum(f)} = \frac{907}{40} = 22.7$

From Table 22 and 23, the respondent's performance in the pre- intervention test exercise indicated that, they had poor understanding of how to balance chemical equations and other related topics that lead to the main concept. Out of the forty (40) learners who participated in the pre-test, 18 had item one to five correct, representing 45% of the sample population. This showed that, pupils cannot correctly assign symbols to elements. A total of 29 (72.5%) pupils were unable to draw the atomic structure of some elements. Only 2 pupils out of (40) scored between 11-16marks correct representing 5%. Again, only one pupil (2.5) out of (40) could balance the chemical equation correctly. This was as a result of the pupils' inability to determine the products in the reactions and assigning the correct coefficients to the chemical entities. It is to be noted that, they had covered the concept in their syllabus. On the other hand, the post test data indicated that, 28 pupils out of 40 representing 70% exhibited complete understanding of the concept. Thirty (30) out of 40 pupils who participated in the study had items 1 to 8 correct representing 80% of the population. 35 pupils (87.5%) had items 9 to 11 correct and of the participants, 29 pupils (72.55%) had items 12 to 21 correct. For items 22 to 26, 26(65%) had them correct and 20 pupils representing (50%) had items 27 to 40 correct. This showed that, success was highly achieved. The mean mark of the class during the pre-intervention test was 9.08 representing 22.7% of the total mark. This implied that, the pupils performed poorly. The poor performance in the pre-test is an indication that, the pupils have difficulties in the writing and balancing of chemical equation. Meanwhile, the mean score of the class in the post-test was 22.7(57%). This indicated that, success was highly achieved. Pupils exhibited complete understanding of how to write and balance chemical equations in the post-test. This skill hitherto could not be displayed by the participants in the study before the intervention was rolled out. Some few pupils could still not balance the chemical equations as a result of not being able to assign the correct coefficients to the equations. This is due to pupil's difference in ability of grasping.

Figure 12: A bar chart representing the frequencies and scores of the performance of pupils pre and post- intervention test

4.1.4 Discussion of results in relation to research question 3

The researcher used three activities, the sticks and holes, the criss- cross and the table activities and a combination of the inspection, traditional and algebraic balancing method to ensure retention of knowledge. Real objects were used to represent the sticks and holes. Blackboard illustrations were done for the criss- cross and the table activities. The criss-cross activity has to do with exchanging valences of various binary compound elements. With the table activity, a line was drawn across the reaction and all the individual elements making up the reactant and products are written in a vertical way to determine same number of elements on both sides. After the intervention, pupil's performance improved significantly with high percentages of those who were able to balance chemical equations. For example, the percentage difference between pupils answering pre-test and post-test question correctly was 50%. This high difference in performance of pupils showed a clear improvement in conceptual understanding demonstrated by learners. This finding is in line with the findings of Charnock (2016),

Research Question 4: **What are the pupils' perception of the use of the activity-based method in balancing chemical equations**?

This question was set to elicit the pupils' responses on their perception of the activity-based method teaching and learning balancing of chemical equation as indicated on table 24.

Table 24: Pupils responses to Questionnaire on their Perception of the Activity-based Method after the Intervention

SN	Premise	Number of respondents=40				
		SAF (%)	AF (%)	UF (%)	DF (%)	SDF (%)
1	I find balancing of chemical equation to be difficult and confusing.	2(5)	2(5)	5(12.5)	11(27.5	20(50)
2	I feel confident to approach and balance chemical equations correctly.	21(52.5	12(10)	2(5)	3(7,5)	2(5)
3	I find balancing of chemical equation interesting.	18(45)	12(30)	6(15)	2(5)	2(5)
4	The practical activities made it simple for me to understand and balance chemical equations with ease.	18(45)	20(50)	3(7.5)		
5	I feel comfortable approaching chemistry topics.	22(55)	20(50)	4(10)	4(10)	
6	I enjoyed the practical lessons of balancing chemical equation	17(42.5	21(52.5	2(5)		
7	I do not feel motivated to learn balancing of chemical equation		2(5)	3(7.5)	20(50)	15(37.5
8	I do not feel bold to pursue chemistry in my next level of education.		2(5)	6(15)	21(52.5	11(27.5
9	I am unaware of the combination of products in the market		3(7.5)	4(10)	16(45)	3(7.5)
10	I feel that I will struggle to grasp concepts chemistry.			3(7.5)	21(52.5	6(15)

Key: SAF = Strongly Agree Frequency, A= Agree Frequency, NF =Neutral Frequency, DF= Disagree Frequency, SDF= Strongly Disagree Frequency. Source: Field data, 2023

The above data from table 24, showed that 75.5% of the respondents disagreed with the assertion that, they found balancing of chemical equation to be difficult and confusing. Twelve point five percent (12.5%) remained neutral and only 10% agreed to the statement. Approximately 82.5% confirmed that, they felt confident to approach and balance chemical equations correctly. 5% stayed neutral and only 12.5% disagreed to it. About 75% of the respondents found balancing of chemical equation interesting, 15% were neutral to the assertion and approximately 10% disagreed to it. About 95% agreed to the fact that, the practical activities made it simple for them to understand and balance chemical equations with ease. Only 3% remained neutral with none of them disagreeing to the assertion. About 80% agreed to the assertion that, they felt comfortable approaching chemistry topics after the intervention lessons.10% were neutral and only 10% disagreed to the statement.95% agreed that, they enjoyed the practical aspect of balancing chemical equation. Approximately 87.5% of the respondents disagreed to the assertion that, they were not motivated in learning balancing of chemical equation. About 80% of the respondents disagreed to the fact that, they were not bold in pursuing chemistry in their next level of education. About 15% of them were neutral and only 5% agreed to the assertion. About 87.5% disagreed to the statement that, they are unaware of the combination of products in the market 10% remain neutral and only 7.5% agreed to the assertion. Finally, 77.5% went contrary to the assertion that, they would struggle to grasp concepts of chemistry.

4.1.5 Discussion of results in relation to research question 4

Activity is the events that students are made to carry out with various concrete materials in order to make a concept (Baserer, 2020). Activity Based Teaching (ABT) is a teaching structure which has significant and natural relation with behaviour, where the stimulants are used before and after behaviour, offering learning opportunities to students. (Pretti-Frontczak, et al, 2003; Pretti-Frontczak & Bricker; 2004; Özen & Ergenekon, 2011). Fletcher & Hicks (2019) asserts that, conceptual learning is a process in which learners organize concept-relevant knowledge, skills, and attitudes to form logical cognitive connections resulting in assimilation, storage, retrieval, and transfer of concepts to applicable situations, familiar and unfamiliar. Greeno, (1998), noted that, curricula can be designed so that concepts are learned in the form of activities where they function and can thereby be understood as resources for practice.

According to the pupils**,** they felt motivated to learn the supposed complicated concept in chemistry. Their conceptual understanding had been promoted, and rote learning had been minimised. Their academic performance also improved.

4.2 Research Findings

4.2.1 Pre-intervention findings

From the pre-intervention tests, the following problems were identified as factors associated with the poor performance of pupils in balancing chemical equations.

- Pupils' inability to assign correct symbol to elements
- Inability of pupils to write electron configuration correctly.
- Inability of pupils to predict the reactants from the product of a reaction.
- Difficulty of pupils in balancing chemical equation. Interviews

4.2.2 Responses from pupils

The responses of pupils from the pre-intervention test indicated that;

- About 72 pupils found it difficult to memorize the first twenty elements in their correct order and their corresponding symbols.
- The concept of balancing chemical equation looked abstract.

- About 69% of pupils were confused with the two-concepts, atomic structure and electron configuration.
- About 70% of pupils found it difficult to identify valences of elements.
- About 75% of pupils found it difficult to write chemical formula of correctly.

Post- intervention responses from pupils indicated that,

- About 68% of the Pupils were able to memorize the first twenty elements in their correct order and their corresponding symbols.
- 70% of the pupils were able to practically balance chemical equations correctly
- About 69% of the pupils could clearly identify each concept distinctly.
- About 80% the pupils could deduce the valences of elements.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.0 Overview

This chapter consists of the summary of key findings and conclusions from the study, recommendations and suggestions for further studies.

5.1 Summary of Key Findings

The following are the summary of the findings of the study:

- The pupils exhibited low performance in the pre-intervention tests which indicated pupils' poor conceptual understanding of the concepts in balancing of chemical equation.
- Pupils exhibited higher performance in the post-intervention tests which indicated an improvement in students' conceptual understanding of the concepts in balancing of chemical equation.

Students' responses to the questionnaire items as well as comments in support of their responses to the questionnaire were mostly in favour of the concept of balancing of chemical equation. This was an indication that in this study, pupils have developed positive perception towards the effective ways of balancing chemical equation.

5.2 Conclusion

The findings of the study showed that the activities used in teaching balancing of chemical equations were effective as it motivated the pupils to learn the supposed complicated concept in chemistry, promoted conceptual understanding, facilitated conceptual changes of pupils, improved academic achievement of pupils and eradicated rote learning. It also stimulated mental model building abilities of learners. This is because activities enabled the pupils to develop problem-solving skills and scientific attitudes. The researcher is of the view that, effective teaching embraces a variety of different aspects of teaching such as subject mastery, effective communication, lesson preparation and presentation, pacing the class to the pupils' level and taking into account individual differences, allowing pupils to practice and applying what they have learnt, letting students know what is expected of them, and monitoring and evaluating performance so that pupils learn from their mistakes.

5.3 Recommendations

To help the JHS two pupils learn more about balancing chemical equations and other aspects of chemistry, the Researcher recommend that, the Sticks and Holes, Criss Cross and the table activities and the three existing methods of teaching balancing of chemical equation namely Inspection,

Pupils should be cautioned to desist from pamphlets because some of them contain errors which they may not be able to identify,

The researcher also recommends that; Socco H/H basic school adopts module for subsequent lessons on balancing chemical equations.

The Traditional and Algebraic methods should be used together by teachers when teaching the concept to consolidate conceptual understanding.

Science educators and curriculum planners should ensure that, topics in science are specifically matched with their corresponding methods of teaching which are tested and proven to be appropriate to enhance the pupils understanding of the subject and not to leave the choice for teachers to make.

The Education Service Directorate must run frequent in-service training workshops for science teachers on modern methodologies employed in the teaching and learning of science.

Government must provide all JHS schools with some science laboratories if possible.

5.4 Suggestion for Further Studies

For the sake of time and financial constraints, the researcher used a small sample size of forty (40) therefore, a larger sample size should be used in further studies to help in the generalization of the results.

Again, further studies should be done using schools in both rural and urban areas to help obtain adequate information on the problem and design more effective approaches in addressing challenges pupils face in understanding difficult concepts in science. Based on the findings of the study, the researcher made the following recommendations to improve pupil's performance.

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APPENDIX A

UNIVERSITY OF EDUCATION, WINNEBA

DEPARTMENT OF SCIENCE EDUCATION

Questionnaire to access respondents' prior knowledge of principles underlying balancing of chemical equation

Instructions: Do not write your name on the paper but write your code. You are assured of the confidentiality of any information provided. Do Individual work. Please tick the appropriate box for your answer.

Code: ………… **Name School: ………………………………**

Key: SA= Strongly Agree, A=Agree, N=Neutral, SD= Strongly Disagree, D=Disagree

SN	Statement	SA	A	N	SD	D
1	The reactants taking part in a chemical reaction are written in symbols					
2	Reactants are ingredient in a chemical reaction					
3	Products are produced from the reaction of substances.					
4	The reactants and products have the same number of atoms of different elements in a balanced equation					
5	The reactants and Products have Equal masses of different elements in a balanced chemical equation					

Appendix A: Continued

6	Identifying the number of elements in a chemical equation aids balancing chemical equation effectively					
7	It is very important to ensure that there is the same number and type of atoms on both sides of a chemical					
8	When combining metals and non- metals, to form compounds, the metals must be placed					
9	It is always important to ensure that the number of atoms of each kind on both sides of the equation is equal					
10	The shells of the atom take the same number of electrons					

APPENDIX B

UNIVERSITY OF EDUCATION, WINNEBA

DEPARTMENT OF SCIENCE EDUCATION

Questionnaire to access respondents' pupils' perception after the going through the activity-based method in studying balancing of chemical equations

Instructions

Do not write your name on the paper but write your code. You are assured of the confidentiality of any information provided. Do Individual work. Please tick the appropriate box for your answer.

Code: ………… **Name School: ………………………………**

Key: SA= Strongly Agree, A=Agree, N=Neutral, SD= Strongly Disagree, D=Disagree

SN	Statement	SA	A	N	SD	D
1	I find balancing of chemical equation to be difficult and confusing.					
2	I feel confident to approach and balance chemical equations correctly.					
3	I find balancing of chemical equation interesting.					
4	The practical activities made it simple for me to understand and balance chemical equations with ease.					
5	I feel comfortable approaching chemistry topics.					
6	I enjoyed the practical lessons of balancing chemical equation					

Appendix B: Continued

7	I do not feel motivated to learn balancing of chemical equation.					
8	I do not feel bold to pursue chemistry in my next level of education.					
9	I am unaware of the combination of products in the market					
10	I feel that I will struggle to grasp concepts chemistry.					

APPENDIX C

INTERVIEW QUESTIONS TO PUPILS

1. Do you find balancing of chemical equation difficult?
2. Can you write the first twenty elements in their correct order and assign their electron configuration?
3. Why do you think balancing of chemical equation is difficult?
4. Are you able to assign number of protons and valences to elements?
5. Are you able to identify metals and non-metals?
6. Do you know which element is placed first when combining elements to form compounds?

APPENDIX D

UNIVERSITY OF EDUCATION, WINNEBA

DEPARTMENT OF SCIENCE EDUCATION

PRE-INTERVENTION TEST

Name of School.................................   **Class**.................................

Pupil Code ....

Instructions

Answer all the questions on the question paper. Individual work is encouraged.

1. Provide the Chemical Symbols of the Following Elements

No.	**Elements**	**Symbols**
I	Chlorine	
II	Calcium	
III	Boron	
IV	Hydrogen	
V	Nitrogen	

2. Draw the atomic structure of the following elements

   a. Hydrogen   b. Sodium

3. State the electron configuration of the following elements

   Chlorine

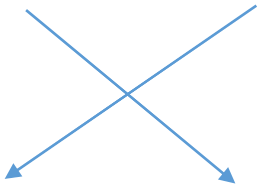
   Neon

   Magnesium

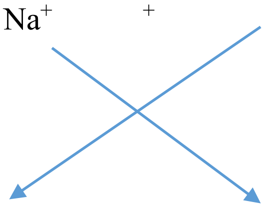
Appendix D: Continued

4. Write the chemical formula of the following

Al^{3+} + O^{2-} →



Na^{+} + O^{2-} →



5. What will be the product of combining 2 atoms of hydrogen and 2 atoms of Oxygen?

6. State the electrical charges on the sub-atomic particles.

7. Write the systematic names of the following simple compounds

a. FeS - NaCl - CuO -

8. Mention the composition of the alloys

a. Steel- Brass - Bronze -

9. Group the following to metals and non-metals. Fluorine, Boron, Calcium, Magnesium,

Metals Non- metals

10. Write the chemical formula of following and balance the equation.

a. $N_2 + H_2 \longrightarrow$

b. $H_2 + O_2 \longrightarrow$

i $H_2 + O_2 \longrightarrow$

ii $CaCO_3 + HCl \longrightarrow$

iii $2NaOH + H_2SO_4 \longrightarrow$

APPENDIX E

UNIVERSITY OF EDUCATION, WINNEBA

DEPARTMENT OF SCIENCE EDUCATION

POST INTERVENTION TEST

Name of School……..……………………….. **Class**……………………………

Pupil Code …………………………………….

Instructions

Answer all the questions on the question paper. Individual work is encouraged.

1. Draw the atomic structure of

   a. Nitrogen

   b. Oxygen

2. State the electrical charges on the sub-atomic particles.

3. Provide the names of the elements with the following electron configuration?

A, 2,5 - B, 2,6- C,2,7-

D, 2,8- E, 2,8,7- F,2,8,8-

4 Identify the constituent elements in the following compounds

i FeS

ii NaCl

iii H_2O

iv MgO

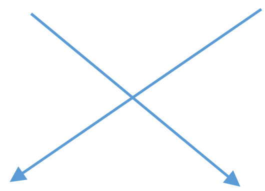
Appendix E: Continued

5. Classify the first twenty elements as metals and non-metals

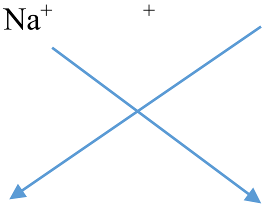
Metals	Non-metals

6. Write the chemical formula of the following

Al^{3+} + O^{2-} →



Na^{+} + O^{2-} →



7. With an aid of a diagram, determine how many sticks and number of;

a. Sodium will be used to fill the holes of Oxygen.

b. Aluminum will be used to fill the holes of Oxygen.

8. Write the word equations of the following compounds

a. Aluminum and Oxygen

b. Sodium and Oxygen

c. Hydrogen and Oxygen

d. Hydrogen and Sulphur

9. State the chemical formulas of the following elements using the crises cross method.

a. Mg and O

b. Al and S

10. Balance the following equations correctly.

i. $H_2 + O_2 \longrightarrow$

ii. $CaCO_3 + HCl \longrightarrow$

iii. $2NaOH + H_2SO_4 \longrightarrow$

Thank you

APPENDIX F

16/30

UNIVERSITY OF EDUCATION WINNEBA

FACULTY OF SCIENCE EDUCATION

DEPARTMENT OF SCIENCE EDUCATION

PRE-INTERVENTION TEST

Name of school. Mamprobi Sacco H/H Basic Class...2...........................

Pupil Code ...003..............................

Instructions; Answer all the questions on the question paper. Individual work is encouraged.

1 Provide the Chemical Symbols of the Following Elements

No.	Elements	Symbols
I	Chlorine	Cl ✓
II	Calcium	Ca ✓
III	Boron	B ✓
IV	Hydrogen	H ✓
V	Nitrogen	N ✓

5

2 Draw the atomic structure of the following elements

a Hydrogen H1

b Sodium Na17 Na

2

3 State the electron configuration of the following elements

Chlorine - 2,8,7 ✓

Neon - 2,5 ✗

Magnesium 2,8,2 ✓

2

Appendix F: Continued

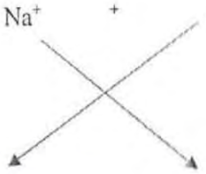
4 Write the chemical formula of the following

Al^{3+} + O^{2-} → Al_3O_3

3 3

Al_3O_3

Na^{+} + O^{2-} → Na_2O



2 1

$Na_2O_1 \Rightarrow Na_2O$

5. what will be the product of combining 2 atoms of hydrogen and 2 atoms of Oxygen?

The product of combining 2 atoms of hydrogen and 2 atoms of oxygen is $= H_2 + O_2 = H_2O$ / Water.

6 State the electrical charges on the sub-atomic particles.

Positive charge –
Nuetral charges
Negative charge

7 Write the systematic names of the following simple compounds

a, FeS - Iron Sulphide NaCl - Sodium Chloride CuO - Copper Oxide

8 Mention the composition of the alloys

a, Steel- Brass - Bronze -

10. Write the chemical formula of following and balance the equation.

i) $H_2 + O_2$ → $2H_2O$

2H - 2 - 4 H - 2 - 4
O - 2 - 2 O, - 2

ii $CaCO_3$ + HCl →

iii 2NaOH + H_2SO_4 →

APPENDIX G

5/30

UNIVERSITY OF EDUCATION WINNEBA

FACULTY OF SCIENCE EDUCATION

DEPARTMENT OF SCIENCE EDUCATION

PRE-INTERVENTION TEST

Name of school. Socco H/ H Basic ..... Class... 2A ....

Pupil Code ... 039 ....

Instructions; Answer all the questions on the question paper. Individual work is encouraged.

1 Provide the Chemical Symbols of the Following Elements

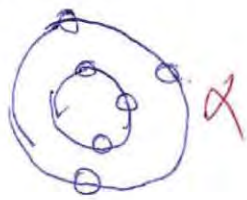
No.	Elements	Symbols
I	Chlorine	Cl ✓
II	Calcium	Ca ✓
III	Boron	B ✓
IV	Hydrogen	H ✓
V	Nitrogen	Ni ✗

(4)

2 Draw the atomic structure of the following elements

a Hydrogen

b Sodium



3 State the electron configuration of the following elements

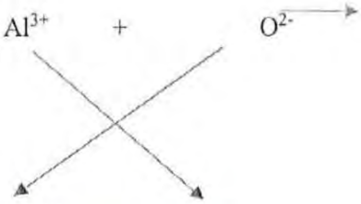
Chlorine

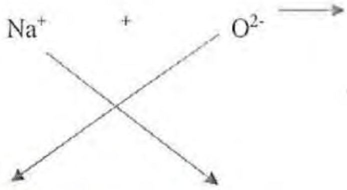
Neon

Magnesium

Appendix G: Continued

4 Write the chemical formula of the following





Ans AlO

Ans = NaO

5. what will be the product of combining 2 atoms of hydrogen and 2 atoms of Oxygen?
~~The product of combining~~ Drinking water

6 State the electrical charges on the sub-atomic particles.

7 Write the systematic names of the following simple compounds

a, FeS - NaCl - Chlorine and Mangnese CuO - Calcium and Oxygen

8 Mention the composition of the alloys

a, Steel- Brass - Bronze -

10. Write the chemical formula of following and balance the equation.

i $H_2 + O_2 \longrightarrow$ ~~He~~ H_2O

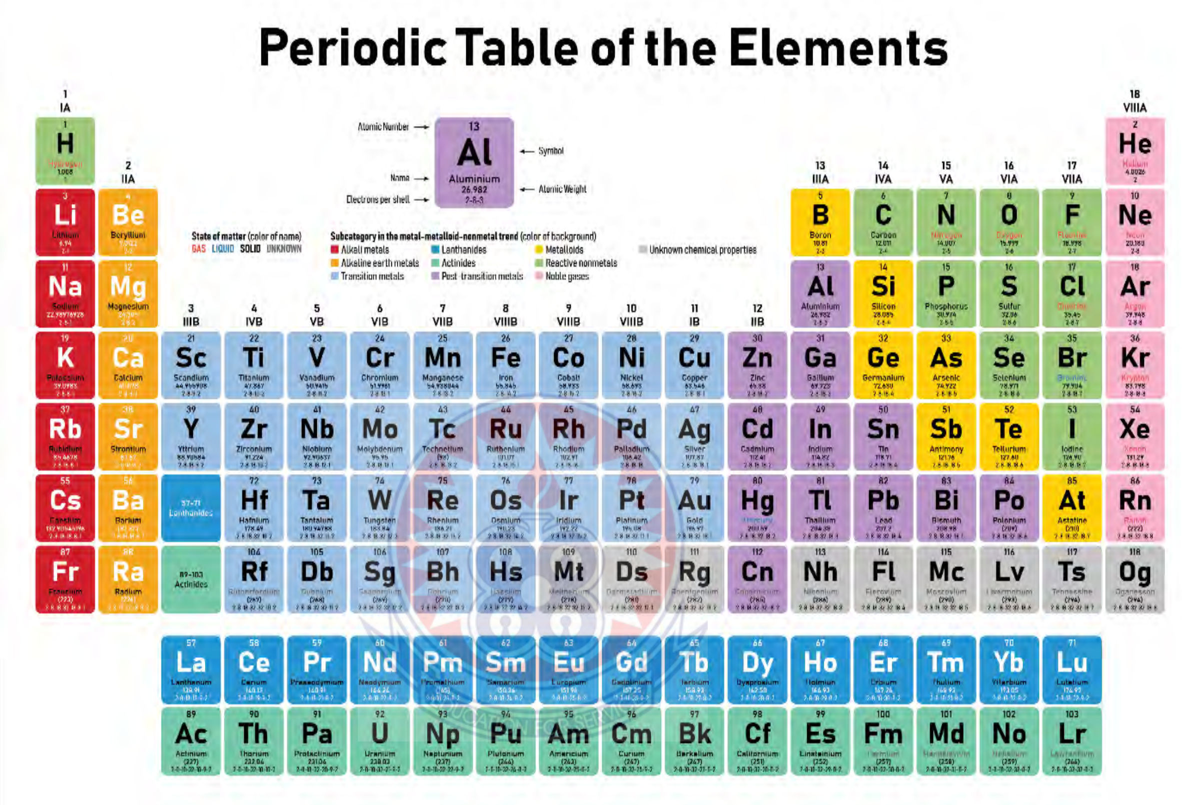
ii $CaCO_3 + HCl \longrightarrow$ CaO_2H

iii $2NaOH + H_2SO_4 \longrightarrow$ N_2aOHS_2

APPENDIX H

A MODULE FOR TEACHING BALANCING OF CHEMICAL EQUATIONS IN JUNIOR HIGH SCHOOL

An Educational Manual to Ensure Pupils Understand the concept of balancing of chemical equation.



HOW TO USE THE MANUAL

This education manual presents a set of five (5) modules which suggests the best ways of teaching balancing of chemical equations through different activities. All modules are made up of two (2) to three (3) activities which spans an hour covering double period as stipulated in the Junior High School (JHS) time table.

Each module is organised into three parts as follows:

1. Learning; -Teaching discussion

   -Drawing and manipulating

Appendix H: Continued

-Practising

2. Retaining; -Class discussions of previous lesson

   -Practising / Demonstration

3. Applying; - Exercises

   -Demonstration

The module will introduce a set of concepts to the pupils. They will be involved in different activities at the end of the lesson, they will be given class exercise to try their hands on.

Each part of the module aims at improving the cognitive abilities of the pupils and to deepen their understanding of the concept of balancing of chemical equation.

Summary of Content

Chapters	Content	Chapter Components	Periods
1	Identifying symbols of elements and their corresponding atomic numbers using mnemonics	➢ Elements compounds and mixtures	Two (2)
2	Electron Configuration	➢ Drawing/stating the configuration of some elements. ➢ Writing of valences. ➢ Classifying the first twenty elements into metals and non-metals.	Two (2)
3	Chemical Compounds	➢ Predicting reactants when products are given.	Two (2)

Appendix H: Continued

		➢ The use of sticks and holes method of writing formula of chemical compounds	
4	Writing Balanced Chemical formula using the criss cross activity and valences.	➢ Writing Chemical formulae from word equations ➢ Writing chemical formulae using valences and the criss cross method.	Two (2)
5	Balancing of Chemical Compounds Equations.	➢ Explanation of a balanced compound. ➢ Balancing Chemical Equations using the table method	Two (2)

1.0 Explanation to Teachers

There would be two phases of the lesson. Each phase will take thirty (30) minutes after which exercises would be given to the pupils to answer. These phases are to ensure learning, retention and application. Steps 1 to 3 would be followed rigidly through every phase and step 4 at the end of each module.

- Step 1: Questions and class discussions
- Step 2: Teacher's demonstrations
- Step 3: Question and answer time
- Step 4: Assigning of class exercises.

Module 1: Identifying symbols of elements and their corresponding atomic numbers using mnemonics

Appendix H: Continued

The objective of the lesson is to guide pupils to:

- Identify and write the symbols of the first twenty elements.
- draw the atomic structures of the elements.

Resources: A chart showing the first twenty elements.

Phase One

Step 1: Questions and class discussions

- Teacher, hang a chart of the first twenty elements on the chalkboard and ask pupils to repeat after you.
- Ask pupils to tell some of the names and symbols of the first twenty elements using an appropriate mnemonic.

Step 2: Teacher's demonstrations

Teacher goes through the names and symbols of the first twenty elements on a chart using the mnemonics below.

Table 1: Names and Chemical Symbols of the First 20 Elements

ATOMIC NUMBER	ELEMENTS	MNEMONICS	CHEMICAL SYMBOLS
1	HYDROGEN	HELLO	H
2	HELIUM	HELENA	He
3	LITHIUM	LISTEN TO	Li
4	BERYLLIUM	B	Be
5	BORON	B	B
6	CARBON	C	C
7	NITROGEN	NEWS	N
8	OXYGEN	ON	O
9	FLOURINE	FRIDAY	F
10	NEON	NIGHT	Ne
11	SODIUM	SOME	Na
12	MAGNESIUM	MINISTERS	Mg
13	ALUMINIUM	ARE	Al
14	SILICON	SELLING	Si

Appendix H: Continued

15	PHOSPHORUS	PITO	P
16	SULPHUR	SO	S
17	CHLORINE	CLIMB	Cl
18	ARGON	ARABA'S	Ar
19	POTASSIUM	KULA	K
20	CALCIUM	CARTER	Ca

Information for Teachers

Pupils should know that, most elements have the first letter or first two letters of their names as their symbols but elements like sodium (Na) and potassium (K) have symbols different from their names. Their symbols are derived from their Latin names. Sodium in Latin is called Natrium and Potassium is Kalium, hence, the symbols for Sodium and Potassium are Na and K respectively.

Step 3: Question and answer time

Teacher ask pupils questions on what has been explained so far and also allow pupils to answer and ask their own questions.

Phase Two

Step 1: Questions and class discussions

- Ask pupils to draw the atomic structure of Helium element.
- Elicit from pupils the maximum number of electrons the first shell carries.

Information for Teachers

The atomic structure contains shells and the shells have their names and the number of electrons they can carry. The first shell, K-shell takes only two (2) electrons. The second shell, L-shell takes a maximum of eight (8) electrons. The M-shell also takes eighteen (18) electrons deriving from the formula $2(n)^2$, where n represents the position of the shell. Pupils are to note that, the position of the element determines their corresponding

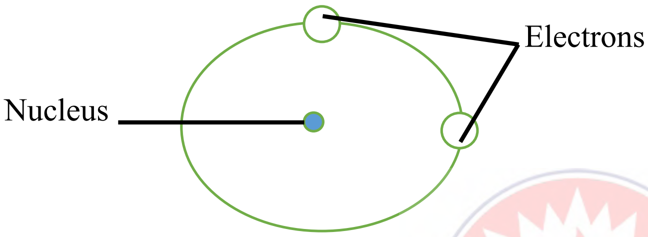
Appendix H: Continued

atomic number. The atomic number represents the number of electrons in the atom of the element.

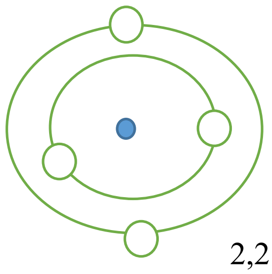
Step 2: Teacher's demonstrations

Teacher demonstrates with pupils the electron configuration of some elements as follows:

THE HELIUM ATOM

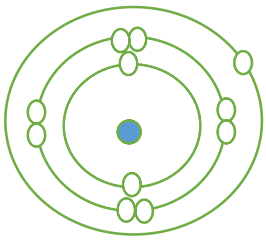


BERYLLIUM ATOM



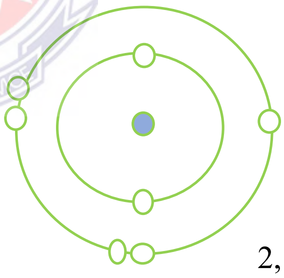
2,2

SODIUM ATOM



2,8,1

NITROGEN ATOM



2, 5

Step 3: Question and answer time

Teacher, quiz pupils on the atomic numbers of nitrogen, calcium, oxygen, Boron, and Neon

Step 4: Assigning of class exercises

Assign pupils to:

1. Write the chemical symbols of the following elements.

    a. Nitrogen

Appendix H: Continued

b. Calcium

c. Oxygen

d. Potassium

e. Sodium

2. Draw the atomic structure of

a. Nitrogen

b. Calcium

c. Oxygen

d. Potassium

Module 2: Electron Configuration

The objective of the lesson is to guide pupils to:

4. Write the electron configuration of elements.
5. determine valences of atoms from their electron configurations.
6. classify elements as metals and non-metals.

Resources: A chart showing the electron configuration of the first twenty elements.

Phase One

Step 1: Questions and class discussions

- call some pupils to the chalkboard to draw the atomic structure of carbon, sulphur and argon as a way of reviewing their previous knowledge.

Information for Teachers

The general formula for determining the maximum number of electrons each shell can accommodate is $2n^2$ where n is the assigned number to a shell. The first shell also called

Appendix H: Continued

the K shell has a value of n = 1. The second shell has n = 2. The third shell M shell has n=3 and the forth shell N has a value of n=4

Step 2: Teacher's demonstrations

- guide pupils to define the electron configuration as the distribution of the electrons of atoms on the atomic shells.
- discuss with pupils the electron configuration of some elements using a chart as indicated in Table 2.

Table 2: Electron configuration of some elements

SN	**Symbol of element**	**Electron configuration**	**SN**	**Symbol of element**	**Electron configuration**
1	H	1	11	Na	2,8,1
2	He	2	12	Mg	2,8,2
3	Li	2,1	13	Al	2,8,3
4	Be	2,2	14	Si	2,8,4
5	B	2,3	15	P	2,8,5
6	C	2,4	16	S	2,8,6
7	N	2,5	17	Cl	2,8,7
8	O	2,6	18	Ar	2,8,8
9	F	2,7	19	K	2,8,8,1
10	Ne	2,8	20	Ca	2,8,8,2

Appendix H: Continued

Step 3: Question and answer time

-Quiz pupils to tell the electron configuration of Silicon, Nitrogen, Carbon and Potassium.

-Pupils should also tell the general formula for determining the maximum number of electrons each shell can carry.

Phase Two

Step 1: Questions and class discussions

- Call two pupils to come to the board and write any two elements and their electron configuration from the deduced electron configurations.
- Find out from pupils how to determine valences

Information for Teachers

It is very important to note that, some elements fill their outermost shells and they are known as noble, rare or inert gases. Therefore, elements would either loss or gain electrons to attain the noble state/gas configuration. The number of electrons lost or gained is therefore the valency of the element.

Step 2: Teacher's demonstrations

Guide pupils developed the table of elements showing their symbols, electron configuration and their valences as shown in Table 3.

Appendix H: Continued

Table 3: Valences of Elements from their Electron Configurations

Atomic No.	Element	Symbol	Electron Configuration	Valency
2	Helium	He	2	0
13	Aluminum	Al	2,8,3	3
9	Fluorine	F	2,7	1
17	Chlorine	Cl	2,8,7	1
8	Oxygen	O	2,6	2
5	Boron	B	2,3	3

Step 3: Question and answer time

Quiz pupils on the valences of some of the elements.

Phase Three

Step 1: Questions and class discussions

- Find out from pupils if they know what metals and non-metals are

Information for teachers

Pupils must know that, all the elements having 1 to 3 electrons are classified as metals while the elements with 5, 6, and 7 in the outermost shell within the first twenty elements are non-meals.

In groups of five, pupils were made

Step 2: Teacher's demonstrations

Put pupils in groups to classify all the twenty elements as metals and non-metals as indicated in Table 4.

Appendix H: Continued

Table 4: Classifying the First Twenty Elements as Metals and Non-metals

Metals	Non-metals
Li	N
Be	O
B	F
Na	P
Mg	S
Al	Cl
K	
Ca	

Step 3: Question and answer time

Allow pupils to ask and answer their own questions if any.

Step 4: Assigning of class exercises

Put pupils in suitable groups for oral quiz on the topic and award marks to the deserving groups.

Module 3: Chemical Compounds

The objective of the **lesson is to guide pupils to:**

-Write formula of binary compounds

- Predict reactants when products of a reactions are given.

Resources: Sample of water, Plastic containers, Nail, plastic objects representing sticks and holes.

Phase One

Step 1: Questions and class discussions

In a discussion, guide pupils to identify the constituent elements from the following compounds FeS, NaCl, H_2O and MgO

Appendix H: Continued

Information for Teachers

Explain to pupils that, products from reactants the species formed from chemical reactions. During a chemical reaction, reactants are transformed into products. Example: hydrated iron (ii) oxide is the constituent of rusting.

Step 2: Teacher's demonstrations

-Teacher, demonstrate to pupils how rust is obtained from the reaction of iron and oxygen in the presence of water. $Fe + 0_{2(g)} \xrightarrow{H_2O} Fe_2O_{3(s)}$. Teacher, explain one after the other the formation of the compounds. Fe is the symbol of iron, O_2 represents Oxygen, H_2O is the symbol of water and the compound formed s Fe_2O_3 which is the chemical formula for rust.

-In a practical demonstration, put a nail in a container, pour water on it up to three quarters (¾) of the container. Leave the container for some days and observe if rust will occur.

Step 3: Question and answer time

- Quiz pupils on the reactants of rust
- Ask them to tell about the formula of rust.

Appendix H: Continued

Phase Two

Step 1: Questions and class discussions

- Give manipulative objects to pupils to identify as sticks and holes

Information for Teachers

- Atoms of elements with 1, 2, and 3 electrons in their outermost shell will be represented as atoms with 1,2, and 3 sticks respectively. On the other hand, atoms of elements with 5,6 and 7 electrons in their outermost shell will be represented as atoms with 3,2 and 1 holes respectively.

Appendix H: Continued

- Explain to pupils also that, metals are elements whose atoms readily give out electron(s) in a chemical reaction and non-metals as elements whose atoms accept electron(s) in a chemical reaction. Pupils should be made to understand that, compounds are formed between metals and non-metals.

Step 2: Teacher's demonstrations

-Teacher demonstrate with pupils using the sticks and holes activity to introduce pupils to how to write the formula of chemical compounds. It is important to note that, the activity demands that, all sticks be used and all holes be filled. This is represented in Tables 5 and 6 below.

Table 5: Number of Electrons and Corresponding Number of Sticks of Elements

Elements	**No of Electrons in Outermost Shells**	**No of Sticks**
1 lithium	1	1
2 Boron	3	3
3 Sodium	1	1
4 Beryllium	2	2
5 calcium	2	2

Appendix H: Continued

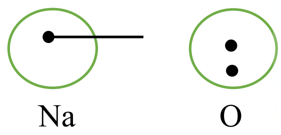
Table 6: Number of Electrons and Corresponding Number Holes of Elements

Elements	No of Electrons in Outermost Shell	No of Holes
1 Phosphorus	5	3
2 Oxygen	6	2
3 Fluorine	7	1
4 Sulphur	6	2
5 Nitrogen	5	3

- Generate with pupils some compounds using the sticks and holes activity.

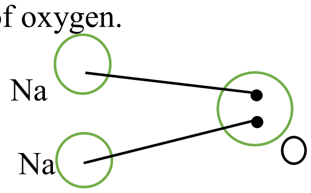
  Example Na_2O, NaCl and Al_3O_2

The formula of the compound of sodium and oxygen is generated as follows.



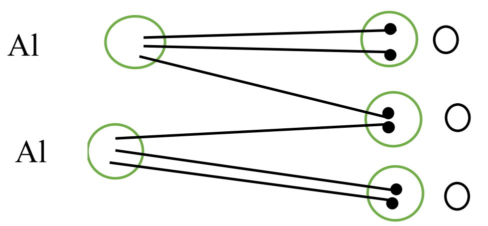
Oxygen has two holes and so, how many sticks of Sodium will be able to fill these holes bearing in mind all holes must be filled and all sticks must be used.

Therefore, two sticks from two atoms of sodium are used to fill the two holes of one atom of oxygen.



Therefore, the formula of the compound formed between sodium and oxygen is Na_2 O.

The compound Aluminum and oxygen was also determined as follows

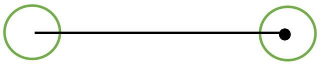


Al_2 O_3

Appendix H: Continued

Two Aluminums are required to fill the six holes of three oxygen.

The compound between Sodium and Chlorine was generated as

Na  Cl One hole is to one stick NaCl.

Step 3: Question and answer time

Quiz pupils on how many sticks are of Oxygen are/is needed to fill how many holes of Sodium?

Step 4: Assigning of class exercises

Assign pupils to write the following chemical formula of compounds to end the lesson.

A reaction between the following:

iv. Magnesium and Oxygen

v. Aluminum and Chlorine

vi. Hydrogen and Oxygen.

Module 4: Writing Chemical formula using valences

The objective of the **lesson is to guide pupils to:**

- Write chemical formulae of compounds from word equations.
- Write chemical formulae of compounds using valences.

Resources – Blackboard illustrations.

Phase One

Step 1: Questions and class discussions

Teacher writes names of elements on chalkboard and asks pupils to write their corresponding symbols in their books.

Appendix H: Continued

Information for Teachers

Make pupils aware of the difference between word equation and chemical equations. Word equations uses words of the elements in the formation of the compound while chemical equation uses the chemical symbols.

Step 2: Teacher's demonstrations

Lead pupils to write chemical compounds from word equations

EXAMPLES: Aluminium and Oxygen $\longrightarrow$ AlO

Sodium and Oxygen $\longrightarrow$ NaO

Hydrogen and Oxygen $\longrightarrow$ HO

Hydrogen and Sulphur $\longrightarrow$ HS

Step 3: Question and answer time

Provide pupils with some word equations and ask them to write their corresponding compounds.

Phase Two

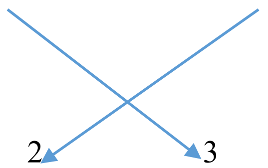
Step 1: Questions and class discussions

Put pupils into sizeable groups and assign each group equal number of elements for pupils to come out with their valences as you ward marks to the groups.

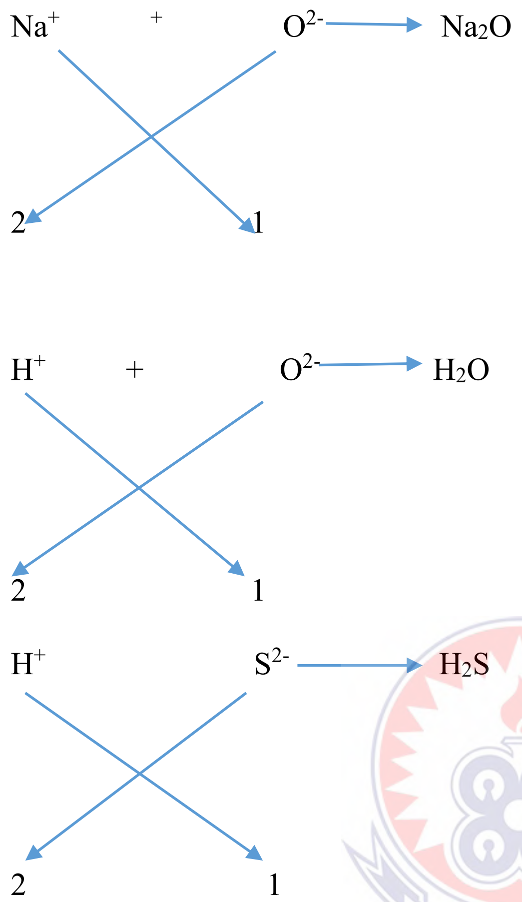
Step 2: Teacher's demonstrations

Teacher, assist pupils to write chemical formulae using the criss cross method as follows:

Al^{3+} + O^{2-} $\longrightarrow$ Al_2O_3



Appendix H: Continued



Step 3: Question and answer time

Quiz pupils on the difference between word and chemical equations.

Step 4: Assigning of class exercises

Write balanced chemical compounds of the following listed compounds below using the criss cross activity and their valences

5. Lead oxide
6. Carbon dioxide
7. Iron (iii) oxide
8. Aluminium chloride

Appendix H: Continued

Module 5: Balancing of chemical compounds / equations

The objective of the **lesson is to guide pupils to:**

- Outline the steps involved in balancing chemical equations.
- Balance chemical equations of binary and complex compounds using the table method.

Resources: A chart showing the table method of balancing chemical equation.

Phase One

Step 1: Questions and class discussions

Call some pupils to the board to write some chemical formulas on the board while other pupils say whether they are correct or wrong.

Information for Teachers

The table activity has the reactants and products on both sides of the equation in a table form. One has to ensure that, both sides of the table are balanced with equal number of molecules.

Step 2: Teacher's demonstrations

Teacher, write some word equations on chalkboard and ask pupils to write its chemical equations.

Example: 1. what will be the product of combining 2 atoms of hydrogen and 2 atoms of oxygen?

Expected Answer: $H_2 + O_2 \quad H_2O$

1. Write the Chemical formula of the compound formed when an atom of Nitrogen combines with atoms of Hydrogen.

Expected Answer: $N_2 + H_2 \longrightarrow NH_3$

Appendix H: Continued

Phase Two

Teacher, led pupils to balance chemical the following equations using table method.

Example 1

$$H_2 + O_2 \longrightarrow H_2O$$

LHS	RHS
H=2	H=2
O=2	O=1

The oxygen is not balanced so we multiply it by 2 so that oxygen will be balanced.

$$H_2 + O_2 \longrightarrow 2H_2O.$$

Hydrogen (H_2) on the other side is not balanced as compared to the hydrogen on the other side. We can therefore balance H_2 by placing 2 in front of it.

Hence the balanced equation is $2H_2 + O \longrightarrow 2H_2O$.

Let's check to see whether all the atoms are balanced on both sides of the equation.

$$2H_2 + O_2 \longrightarrow 2H_2O$$

LHS	RHS
H=4	H=4
O=2	O=2

Example 2 $N_2 + H_2 \longrightarrow NH_3$

LHS	RHS
N-2	N-1
H-2	H-3

Appendix H: Continued

The nitrogen at the right hand side is not balanced so let's multiply the NH_3 by 2 as

$$N_2 + H_2 \longrightarrow 2NH_3.$$

H_2 at the left hand side is not balanced as compared to H on the right hand side. So let's multiply H_2 by 3 as.

$$N_2 + 3H_2 \longrightarrow 2NH_3.$$

Let's check to see whether all the atoms are balanced on both sides of the equation.

$$N_2 + 3H_2 \longrightarrow 2NH_3.$$

LHS	RHS
N-2	N-2
H-6	H-6

The equation is therefore balanced.

We really appreciate your feedback after using this module.

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Thank you.