Effect of Graphic Organizers on Performance and Retention in Writing and Balancing of Chemical Equations by Grade 11 Pupils at Temweni Secondary School, Ndola

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Abstract: **Viable evidence indicates that in spite of frantic efforts put in place by Ministry of General Education such as the fast track training of Science teachers, introduction of a practical examination, abolishing of a complete theory multiple-choice question paper and having two separate theory papers for chemistry and physics following the revision of the curriculum so as to improve performance in science subjects, the performance of students still remains below average in science subjects particularly chemistry. The recent 2019 examinations results have also indicated that the performance of students in science subjects was below average. Therefore, this study sought to investigate the effect of graphic organizers on students' performance and retention in writing and balancing of chemical equations. The design of the study was a counter-balance quasi-experimental non-equivalent group. The sample composed of 111 grade eleven pupils comprising 51 boys and 60 were girls. The study was conducted in two phases and lasted for six weeks. The first phase was conducted for a period of 3 weeks. During this period the experimental group was exposed to the treatment, the graphic organizers, and the control group was taught using lecture method there after post-test1 was administered. The second phase started in the fourth week and lasted for 3 weeks as well. In this phase the control group was exposed to the intervention the graphic organizers while the initial experimental group was taught using lecture method there after post-test2 was administered.**

Two instruments were used to collect quantitative data, and this include chemistry achievement test (CAT) and attitude and belief questionnaire. These instruments were administered once before and once after the intervention. The scores of the subjects before and after the graphic organizers intervention were compared and analysed quantitatively using a computer program SPSS and the hypotheses were tested using independent-samples t-test at 0.05 level of significance to determine whether there was any significant differences between means of the scores. The data generated through the questionnaire was analysed using the SPSS and presented on the frequency table and bar chart to determine whether there was some changes in student's attitudes and beliefs.

The results of this study showed that graphic organizers such as ranking ladder and chain of linked events had significantly improved the performance and retention of students and had positively impacted the student's attitudes and beliefs towards writing and balancing of chemical equations. These results also suggest that graphic organizers can be an effective supporting tool in teaching and learning of learners.

Key words: **Graphic organizers, Counter-balance, Ranking ladder organizer, Chain of linked event organizer and systematic inquiry.**

I. INTRODUCTION

1.1 Background of the study

Chemistry is seen as a difficulty, complex and an abstract subject that requires special intellectual talents and a too much effort to be understood (Gabel, 1999, John stone, 1991; Ankle, 1992, Ben-VI; Eylon and Silberstein, 1987). Chemistry is considered a difficult subject by many students because some chemical symbols are confusing, for example the chemical symbol for sodium instead of writing So it is written as Na which is the chemical symbol for its Latin name called Natrium (Jeol,2015).The use of Latin names instead of English names make students to be more confused and fail to grasp the concept, therefore, creates an additional barrier to learn chemistry(Jeol,2015).Another barrier in chemistry is the use of mathematics. Those students who are mathematically challenged find chemistry tough because they have to use mathematics to calculate the number of moles or in balancing chemical equations, therefore ,no one can run away from mathematics (Jeol,2015).Sometimes students use their calculator and get $3.8x10^{-3}$ as their answer, which might be correct but they interpret it as 0.00038(it should be 0.0038), as a result they find chemistry tough and this is due to their weak foundation in mathematics that hinders them from excelling in chemistry. According to Joel liu (2015), he stated that the other reason why many students consider chemistry as a tough subject is that chemistry uses both memory and problem-solving skills. There are some students who excel in subjects who only deal with or depend on memory work, such as Biology and History. Others they tend to excel in subjects that rely on logical thinking and problem-solving skills, like mathematics and physics. Chemistry is a unique subject which sits in between these two skills. There is memory work involved, yet students also have to apply their problem-solving skills to answer questions. This is why students often

struggle in chemistry, as one who has either skill set would do well in certain subjects but not chemistry. Therefore, for any student to do well in chemistry needs to be equally adept at both. Chemistry curricula commonly incorporate many abstract concepts which are central to further learning in both chemistry and other sciences (Taber ,2002).These abstract concepts are important because further chemistry/science concepts or theories cannot be easily understood if these underpinning concepts are not sufficiently grasped by the student(C0II & Treagust,2001;Nicoll,2001).The abstract nature of chemistry along with other content learning difficulties e.g. the mathematical nature of much chemistry means that chemistry classes require a high-level skill set(Fenshan,1998,Zoller,1990;Taber,2002). "However," perhaps more than other sciences understanding chemistry rely on making sense of the invisible and the untouchable" (Kozma&Russell, 1997, p.949). John stone (1974), in his early study, reported that the problem areas in the subject from pupils point of view are the mole, chemical formulae and equations and in organic chemistry condensations and hydrolysis. Chemistry knowledge is learned at three levels:" sub-microscopic, macroscopic and symbolic, "and the link between these levels should be explicitly taught (John stone, 1991, Gabel, 1992, Treagust et al, 2003). John stone (1991) indicated that the nature of chemistry concepts and the way the concepts are represented make chemistry difficult to learn. The methods by which students learn are potentially in conflict with the nature of science which in turn, influences the methods by which teachers have traditionally taught (John stone, 1994).Chemistry learning requires much intellectual thought and discernment because the content is replete with many abstract concepts such as dissolution particulate nature of matter, and chemical bonding are fundamental to learning chemistry (Abraham et al, 1992)

Real understanding requires not only the grasp of key concepts but also the establishment of meaningful links to bring the concepts into a coherent whole.

Asikhia (2010), found that, qualification of teachers and students environment factors do not influence students poor performance but teachers methods of teaching influence poor academic performance. The commonly used teaching methods especially in developing countries are teacher-centred (Guloba, Wokodola, & Bategeka, 2010), which are viewed to be some ineffective in the impartation of knowledge. Ndirangu (2007), suggested adopting a learner-centred paradigm shift, other schools of thought are advocating participatory methods of teaching (Sajjad, 2011). Learner-centred activity oriented method may include the use of Graphic organizers.

Therefore, integrating an innovative method which is Graphic Organizers to teach chemistry can be supportive of teacher's teaching and students learning (Hall &Strongman, 2002).

Bishop (2013) defined Graphic Organizers as visual display of key content information designed to guide students and enhance their comprehension. A Graphic organizer (GO) is simply a graphical or spatial representation of text concepts. The spatial arrangements of GOs allow the students to identify the missing information or absent connections in one's strategic thinking (Ellis, 2004).

According to Myers & Savage (2005), GOs are a research based strategy that promotes comprehension and aids in students learning with the complex content.

Graphic organizers are non- linguistic, visual tool that enable the learner to connect new information to their existing knowledge and see how concepts relate to each other and fit in, which in turn make them recall information easily.

Lee (2004) regards graphic organizers as the most effective tools for teaching and improving writing skills. In fact, dozens of empirical studies were conducted to verify the efficacy of such organizers, and almost all of these studies asserted their viability for teaching writing. It is found that these organizers help the students visualize the abstract ideas, divide the writing tasks into smaller palatable parts, and monitor their writing progress (Unzueta, 2009).

Graphic organizers are defined by Bishop (2013) as visual displays of key content information designed to guide learners and to enhance their comprehension. They are sometimes referred to as concept maps, cognitive maps, or content maps, but they are all used to serve one purpose. They are meant, says Baxendell (2003) to help students clearly see how ideas are organized within a text or surrounding a concept. Through the use of organizers, learners acquire the structure of abstract concepts.

Graphic Organizers such as Ranking ladder and Chain of linked events are visual representation models or illustrations that depict relationships among the concepts.

In graphic organizers, learning materials are broken down into small steps that are arranged sequentially from known to unknown and in an increasing order of difficulty or complexity. In this study the ranking ladder show the increase in the level of knowledge as the student write and balance the chemical equation from one rung to the next and also in chain of linked events the student is able to see the links between the types of chemical reactions.

It has been observed that effective teaching may facilitate learning and make it more meaningful. In line with this, Sander (2001) stated that effective teaching helps the student to learn better, while poor teaching would naturally lead to poor learning and consequently poor achievement.

Studies carried out by Udousoro (2002), and Udeji (2007), showed that the methods employed in teaching Science led to students high retention and achievement. These findings suggest that there is need to carry out more studies to clarify issues related to achievement and retention as it concerns methods of teaching used in teaching. Since there is no consensus on the effect of methods on students retention and

achievement, there is need to investigate a learner-centred activity oriented method and its effect on achievement and retention. Therefore, this study is designed to do research on the effect of graphic organizers specifically ranking ladder and chain of linked events on performance and retention in writing and balancing of chemical equations which is the backbone of the language of chemistry without which students would not speak the chemistrian language. The researcher is trying to find out if the already mentioned graphic organizers can be the supplement teaching method to the number of methods teachers use to teach chemistry and other science subjects.

Meyen et al (1996) stated that GOs are "visual displays teachers use to organize information in a manner that makes the information easier to understand and learn". According to Zaini, S. H. Mokhtar S.Z. &Nawani. M. (2010), stated that the idea of GO is based on Ausubel's assimilation theory of cognitive learning (Ausubel et al, 1978).According to them the information is organized by the mind in a hierarchical top and down fashion. The cognitive approach to learning seeks to understand how incoming information is processed and structured into memory.

Ausubel (1963), Suggested that the use of GOs greatly influences learning by providing students with a meaningful framework to relate existing knowledge to new information. GOs give the students a means to organize the material, recognize the key concepts and focus on the important information (Farris, 2001). According to Clark (2007), GOs not only enable students to record and categorize information, but also help students to understand difficult concepts, generate thoughts, and identify connections between ideas.

Farris (2001) suggested that GOs give the students control over the text and assist in comprehension. Gallavan and Kotler (2007), also suggested that GOs aid in student motivation, short term recall, and long term, achievement by allowing students to summarize, manipulate, and manage the complex subject content.

Ekere Mathias (2014) stated that writing and balancing of chemical equations is the backbone of understanding the language of chemistry of which without mastery of it, students finds every other aspect of chemistry difficult. Therefore, integrating a new teaching technique such as GOs instead of the note-taking method which makes students passive in learning process can help student to be active throughout the learning process.

Janssen (1998) asserted that GOs are generalizable tools that can facilitate cognitive processing and communicate the logical structure of the instructional materials

Despite the various frantic efforts done by the ministry of general education such as the introduction of a science practical paper, there seem not to be much improvement in students' perfomance in science particularly chemistry. Several researches including Okeke (2008), Orasi (2007) and Okoli (2011) have reported low academic achievement and low enrollment of senior secondary school students in chemistry. The root of this problem may be attributed to poor instructional approach. Oka (2008) pointed out that the type of instructional approach plan used by teachers determine how effective learning can be, hence good teaching makes learning more meaningful. As a result there is need for chemistry teachers to shift from standardized teacher-directed instruction to a more active teaching environment where students can participate actively and make use of their creative minds rather than remain passive. The learning process in which students are actively involved would likely lead to meaningful learning and not rote learning. Researchers like Oku (2008) and Okeke (2008) observed that most of the chemistry teachers in Nigeria senior secondary schools use talk-and – chalk method when teaching chemistry. This method of teaching encourages rote learning and regurgitation

Rosemund (2006), opined that attitude implies a favorable or disfavorable evaluative reactions towards something, events, programmes, etc. exhibited in an individual's beliefs, feelings, emotions or intended behaviors.

Reports recorded from studies done by Anyelaagbe (1998), Udousoro (2000) and Popoola(2002), indicated that students show more positive attitudes after been exposed to self-learning strategy, such as computer and text assisted programmed instruction, self-learning device and self-instructed problem based. Attitude, therefore affects people in everything they do and in fact reflects what they are, hence a determining factor of student's behavior (Aiken, 2000).

The study done by (Milano, Rebecca, & Antrim an Orleans, 2014) on Integrating Graphic Organizers in facilitating learning of Chemistry in Philippines, focused specifically on determining the attitude toward Chemistry and achievement of two groups of students under study.

The study indicated that there is a significant difference between attitude toward Chemistry of students in the Experimental group before and after the experiment. The results of student's perception about Graphic Organizer, as teaching strategy and approach to teaching Chemistry, indicated the rational in this undertaking. All presentations used by the teacher in the class incorporating graphic organizers in identified formats such as wed diagram, flowchart-concept map, Venn diagram and pictorial graphs obtained a good and very good perception.Performance,on the other hand,indicated,ultimate measure of graphic organizers' effectiveness in facilitating learning. This analysis implied that the Experimental group performed significantly better than their counterparts in the Control group with adjusted means scores of 47.45 and 39.11, respectively. Facilitating learning Chemistry can be made through integrating graphic organizers. Graphic organizer based presentation solicited and indicated positive attitude from the students. Hence, the use of graphic organizers effect changes in behavioral dimensions of learning content for the better. Graphic organizers as

conditions can make students perform well and may seem to improve their attitude toward learning. Graphic organizer is apparently indicating success as critical index of learning. It is recommended that graphic organizers be used by teachers to improve attitude and ach Enekwe(2016) in his study examined the effect of advance organizers on secondary school students' academic achievement in chemistry and their scientific attitude. He used the pre-test and post-test control group quasi-experimental design with eighty four senior secondary2(SS2) chemistry students as subjects selected from two sampled schools. Chemistry Achievement test (CAT) and Scientific attitude Questionnaire (SAQ) were the instruments used for collection of data. The reliability of the CAT was finally determined using Spearman-Brown formula which yielded a coefficient of 0.82 while the Cronbach Alpha reliability coefficient for SAQ was 0.91. Analysis of covariance (ANCOVA) was used as the statistical technique for the data analysis. The hypotheses were tested at 0.05 level of significance. The findings indicated that students taught chemistry with advance organizers achieved better and had a higher level of scientific attitude than their counterparts taught with the conventional method. The study therefore, recommended that chemistry teachers should adopt the use of advance organizers in order to improve student's achievement and scientific attitudes.

The study done by Okeke(2011) on effect of mind mapping teaching strategy(MMTS) on students'achievement,interest and retention in senior secondary school chemistry in Nigeria showed that the MMTS has significant effect on students cognitive achievement, interest and retention in chemistry. The MMTS is more efficacious than the Conventional teaching method (CTM).The influence of gender on mean achievement score and mean interest score were significant but mean retention score was not. Female students showed to be superior to their male counterparts. The interaction effect of gender and treatment on the mean achievement score and the mean interest score were significant but not on the mean retention score.

Akpan (1988) carried out a study to identify the major areas of students' difficulties in the content of school certificate chemistry. It was found that some students perceive some chemistry topic as being difficult relative to others: electrolysis, atomic structure, writing and balancing of chemical equation, chemical equilibrium and oxidation and reduction among others.

1.2 The performance of students in Chemistry.

Performance in chemistry depends on many factors and stands out to show how well a student is doing. Festus (2007) contend that performance appears generally to be the fundamental goal behind every life struggle, but the positive platform has consequential effects of improving the worth of student and can only be achieved through acquisition of positive learning attitude. In order to solve chemistry problems in an acceptable manner, the problem solver must have both conceptual scientific and procedural knowledge (Gabel, 1994, Ekpete, 2002). However, many studies showed that students frequently do not use conceptual understanding in solving chemistry problems.

Examinations council of Zambia performance report of 2016 indicated that the candidates' performance was low in the topics like chemical formulae and chemical equations, mole concept, acids, bases, salts, non-metals and organic chemistry. The same trend was also indicated in Examination performance review report of 2017 where it was reported that candidate's performance was low in the same topics already mentioned in 2016 performance report.

Some studies also provided evidence that students were limited in their ability to solve distance transfer problems without an in-depth understanding of relevant chemistry concepts. Nakhleh (1993) opined that chemical educators and teachers have often assumed that success in solving chemistry problems should indicate mastery of the chemistry concepts. According to Greenwald (2000), the best way for students to learn science is to experience challenging problems and the thoughts and actions associated with solving them.

According to Bassey, Umoren and Udida (2008), students' academic performance in chemistry is a function of their attitude. Papanastasiou (2001) reported that those who have positive attitude toward science tend to perform better in the subject.

1.3 The performance of students in writing chemical equations.

A chemical equation is an expression that uses symbols to describe a chemical reaction (Michael Dispezio, et al. 1997). Since the same chemical symbols are used world-wide, a chemical equation can be understood in any country in the world (Marylyn Lisowski, et al. 1997). An equation is like a sentence in chemical terms which begins on the left hand side with the formulae of the starting materials called the reactants which undergo a chemical change. The sentence ends with the formulas for the new substances formed by the reaction called the products. A chemical equation is a language through which chemists communicate information about a chemical reaction. Chemical equations enable chemists from different countries to communicate with one another without error.

Writing and balancing of chemical equation is so fundamental that without mastery in it, students find every other aspect of chemistry difficult (Ekere Ugwu, 2014). Agarwal (2004) draws attention to the importance of the ability to write and balance equations of the chemical reactions in the process of learning chemistry, but also writes about the difficulties students experience when writing and balancing equations of chemical reactions.

The study done by Ekere Matthias (2014) revealed that students have difficulties in writing and balancing chemical equations at various class levels of senior secondary school because (i) students lack the knowledge of writing correct

formulae of the compounds reacting (ii) students lack the knowledge of valence of atoms in the formulae of compounds (iii) they have poor knowledge of rules guiding the balancing of equations and finally (iv) they are not able to check each atom on both sides of the equation to make sure that the coefficient used are all whole numbers and are reduced to their lowest terms. Not only that but to check also whether the principle which states that matter is neither created nor destroyed during chemical reaction is obeyed.

2016 Examination performance report of Examination council of Zambia indicated that most of the candidates had challenges in writing correct chemical symbols and equations. 2017 School certificate ordinary level Examiner[s] report in chemistry 5070/3, indicated that most candidates lost 1 mark for failing to balance a chemical equation, also in science particularly chemistry it was indicated that candidates performance was low in the topics such as chemical formulae and chemical equations, mole concept to mention but a few. The concept of writing and balancing of chemical equation of chemical reactions is of great importance because it gives certain information about a chemical equation. Bajah, Teibo, Onwu, Obikweze (1999) stated that the pieces of information conveyed by chemical equation include:

1. The molar mass of each compound can be calculated from relative atomic masses of the elements forming the compound.
2. Reactions between substances whether elements or compounds, take place in simple whole numbers of moles of those substances. Thus the equation $CuSo_{4(aq)} + BaCl_{2\,(aq)} \longrightarrow CuCl_{2\,(aq)} + BaSo_{4\,(s)}$ conveyed the information about number of moles of the reactants and the number of moles of the products, so in this case 1 mole of $CuSo_4$ reacts with 1 mole of $BaCl_2$ to form 1 mole of $CuCl_2$ and 1 mole of $BaSo_4$.
3. From the molar mass, the reacting masses of the substance are known that is 1 mole of $CuSo_4$ has mass of 159.6g, 1 mole of $BaCl_2$ has a mass of 208g, 1 mole of $CuCl_2$ has a mass of 134.6g and 1 mole of $BaSo_4$ has a mass of 233g. These are the ratios of the masses of the reactants and of the products. From these ratios any reacting mass can be found.
4. If a reactant or product is a gas, then its volume can be determined from its mass, by using the fact that the molar volume is $22.4dm^3$ at STP (Standard Temperature and Pressure).
5. The letter's', 'g' and 'l' commonly called state symbols denotes Solid, Gas and Liquid respectively while 'aq' denotes aqueous, as illustrated in the following equation

$$CuCo_{3\,(s)} + H_2So_{4\,(aq)} \longrightarrow CuSo_{4\,(s)} + Co_{2\,(g)}\, H_2O_{\,(l)}.$$

Therefore, the concept of balancing chemical equations has been recognized as one of the basis of chemical concepts in chemistry, as suggested by Ababio, (2004). Anthony (2009) reported that the understanding of balancing chemical equation is a prerequisite to the comprehension of some learning tasks in chemistry such as chemical equilibrium, electrochemistry, and organic chemistry. Balancing of chemical equations also is one of the difficult concepts chemistry students encounter in both practical and theory. This is supported by ECZ chief examiner[s] reports of 2015,2016 and 2017, which ascertained that, what made most chemistry students perform poorly in chemistry was the inability of the students to write correctly, reactants, products as well as to balance the reaction equation correctly. All these are attributed to poor teaching methods, lack of adequate practical equipments, mathematical nature of chemistry concepts and laws (Ayogu, 2001). Therefore this problem can be solved by using activity- oriented instructional method, which is a graphic organizer such as Ranking ladder and Chain of linked events.

1.4 The effect of GOs on attitude.

Rosemund (2006), opined that attitude implies a favorable or disfavorable evaluative reactions towards something, events, programmes, etc. exhibited in an individual's beliefs, feelings, emotions or intended behaviors.

Reports recorded from studies done by Anyelaagbe (1998), Udousoro (2000) and Popoola(2002), indicated that students show more positive attitudes after been exposed to self-learning strategy, such as computer and text assisted programmed instruction, self-learning device and self-instructed problem based. Attitude, therefore affects people in everything they do and in fact reflects what they are, hence a determining factor of student[s] behavior (Aiken, 2000).

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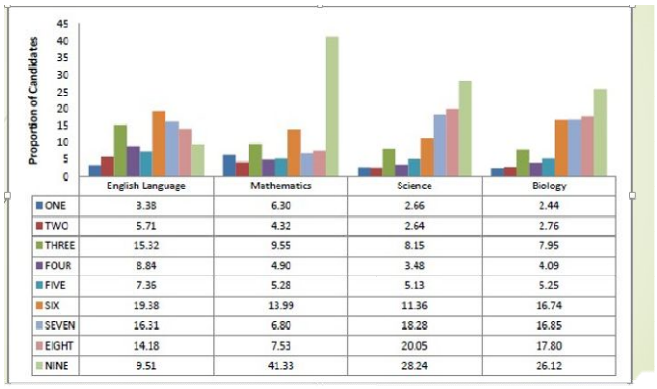
1.5 Statement of the problem

Regardless of many efforts put in place by the Ministry of General Education to improve performance in science subjects like the fast track training of science teachers and also reviewing of the curriculum by introduction of a practical examination abolishing of a complete theory multiple choice question paper and having two separate theory papers for chemistry and physics which in turn made science to record an improvement when compared from 32.8 percentage in 2016 to 43.58 percentage in 2017, the performance of students still demands a lot to be done. This is seen in 2016 grade 12 grade distribution for science 5124 where it is indicated that the number of candidates scoring a 9 or unsatisfactory is still high, about 35,253 against 3,350 candidates scoring a grade 1 which gives 27.9 percentages with a grade 9 and 2.65 percentages with a grade 1.

The same trend can be seen in 2017 grade 12 Examination council of Zambia-Results Highlights for the 4 common subjects that is English, Mathematics, Science and Biology, in which it has been indicated that the percentage of students scoring a grade 9 is higher than the students who scored a grade 1 in science, as shown in the figure below;



	English Language	Mathematics	Science	Biology
ONE	3.38	6.30	2.66	2.44
TWO	5.71	4.32	2.64	2.76
THREE	15.32	9.55	8.15	7.95
FOUR	8.84	4.90	3.48	4.09
FIVE	7.36	5.28	5.13	5.25
SIX	19.38	13.99	11.36	16.74
SEVEN	16.31	6.80	18.28	16.85
EIGHT	14.18	7.53	20.05	17.80
NINE	9.51	41.33	28.24	26.12

Figure 1. 2017 Grade distributions in four selected common subjects (source ECZ Examination Results Highlights 2017)

Figure 1.1 revealed that 28.24 percentages of students got a grade 9 while 2.66 percentages of students got a grade 1 in Science.

Science is the combination of physics and chemistry, so if i divide 2.66 by 2 to get the percentage for chemistry, or if chemistry mighty performed better than physics, the percentage for chemistry still would be very low compared to the fraction i would get from the total percentage of students who got a grade 9 which is 28.24%.

From what is shown on the figure above, a grade 9 has the highest mean percentage except in English Language this simply mean that a lot of students are still failing Science subjects particularly Chemistry. This poor performance of students in science subjects particularly chemistry is not only at national level, but also at secondary school level the table on Appendix F shows how the grade 12 at Temweni secondary school which is the site of this study performed in chemistry in their end of term one examinations in April 2019 shown in teacher tracking tool for classes taking science 5124.

The number of students sat for end of term one and their results in test 1, test 2 and the end of term are shown in red in the table so that it can be followed clearly, again the results are not pleasing despite the review of the curriculum, sending a lot of science teacher on fast track training, and also the introduction of a practical paper, most of the students get poor results or fail the examinations especially in science subjects particularly chemistry.

Various efforts have been geared towards improving the pedagogical approaches and many other activities mentioned above already, but the performance of students still remains not pleasant. This below average performance in science subjects especially chemistry has raised a concern due to the reason being that Zambia aims at achieving her aspiration of becoming a prosperous middle income country by 2030 through science and technology education.

This study therefore, sought to investigate the effect of graphic organizers on performance and retention in writing and balancing of chemical equations. Writing and balancing

of chemical equations is the backbone of understanding chemistry. 2017 chief examination report indicated that most students didn't perform well in chemical formulae, chemical equations and mole concept. The study also is trying to find out if graphic organizers can supplement the already used methods of teaching and learning of chemistry.

1.6 Research Objectives

1. To determine whether graphic organizers have an effect on performance of students.
2. To find out whether graphic organizers have an effect on students' retention of the concepts.
3. To find out whether or not graphic organizers impact students attitudes and beliefs positively towards writing and balancing of chemical equations.

1.7 Research Questions

1. What effect does Graphic Organizers specifically ranking ladder and chain of linked events have on performance mean score of students taught with GOs and those taught without GOs?
2. What effect does Graphic Organizers have on retention mean score of students taught with GOs and those taught without GOs?
3. Does the use of graphic organizers impact the student's attitudes and beliefs towards writing and balancing of chemical equations positively?

II. METHODOLOGY

2.1 Design of the Study

Design of the study or Research design is a mapping strategy or the choice of the researcher about components of his/her project (Singh, 2006).

The design of this study is a counter-balance quasi-Experimental design of the non-equivalent design (Campbell & Stanely, 1967).

Phase I	
Experimental group. Topic: Atoms, Elements and Molecules. Sub-topic: chemical formulae and equations. Method of instructions: Graphic organizers. Duration: 80 minutes twice per week for a period of 3 weeks.	Control group. Topic: Atoms, Elements and Molecules. Sub-topic: chemical formulae and equations. Method of instructions: Lecture method. Duration: 80 minutes twice per week for a period of 3 weeks.
Phase II	
Control group. Topic : Ionic Equations Sub-topic: writing net ionic equations. Method of instructions: Lecture method. Duration: 80 minutes twice per week for a period of 3 weeks.	Experimental group. Topic : Ionic Equations Sub-topic: writing net ionic equations. Method of instructions: Graphic organizers. Duration : 80 minutes twice per week for a period of 3 weeks,

Counter balancing is a procedure that allows researcher to control the effects of nuisance variables in designs where the same participants are repeatedly subjected to conditions, treatments, or stimuli (e.g. within-subjects or repeated-measures designs).Counter balancing refers to the systematic variation of the order of conditions in a study, which enhances the study internal validity. In the context of experimental designs the most common nuisance factors (confound) to be counterbalanced are procedural variables that are temporal or spatial position that can create order and sequence effects. In quasi-Experimental designs, blocking variables (e.g., age, gender) can also be counterbalanced to control their effects on the dependent variable of interest, thus compensating for the lack of random assignment and the potential confounds due to systematic selection bias.

2.2 Site of the Study

This study was conducted at Temweni Secondary School in Chifubu township of Ndola District of copper belt province of Zambia.

Chifubu Township is on the northern part of Ndola District and there are six (6) secondary schools. Four out of the six secondary school were recently up graded to the status of combined secondary schools, as a result they don't have grade 11 classes yet, and the other secondary school have only one class for grade elevens. Therefore Temweni secondary was purposively selected by the researcher due to the reason being that it had many classes for grade elevens, about four grade elevens classes taking science 5124, and only two classes were used in this study. The township was selected owing to the reason being that it is near the researcher residence,

therefore, the researcher had easy access to collect the required data.

2.3 Population of the Study

The population of the study comprised of *353* students from four (4) classes taking Science (5124), in 2019.

2.4 Sample and sampling Techniques

The sample used for the study consisted of a total of 111(5124) Science students (51 boys and 60 girls) drawn out from four grade Eleven classes at Temweni Secondary School. The four classes were purposively selected because they are the only classes taking Science 5124, the remaining class takes chemistry5070.Following the design of the study, only two intact classes was used, and therefore, the two classes were randomly assigned through simple random sampling (balloting).

The subjects of the study were not randomized, because they are intact classes. The selection of classes for either of the instructional methods was not randomized as well, because the design of the study is counterbalance ,consequently, each class had an opportunity to be exposed to the treatment or intervention.

2.5 Instruments for data collection

Two instruments were developed by the researcher for data collection. They are the Chemistry Achievement Test (CAT) and the Questionnaire for attitude and beliefs (ABQ).

2.5.1 The Chemistry achievement test (CAT) was for collection of pre-test achievement score, post-test1 achievement score, post-test2 achievement score and retention test score. The pre-test was used as the retention test. The Chemistry achievement test comprised of four(4) questions of which the first three (3) questions each contained five sub-questions, where each question is scored 1 mark ,and question four(4) had two sub-questions and each question is scored $2\frac{1}{2}$ marks ,giving the total marks for the whole paper is 20 marks.

2.5.2 The attitude and belief questionnaire (ABQ) was for collection of student's attitudes and beliefs or perception before and after the treatment.

The questionnaire was developed by the researcher as already mentioned to determine the attitudes and beliefs that students had towards writing and balancing of chemical equations. The questionnaire had 14-closed items which used 1 to 5 rating Likert scaling. (1-Strongly disagree, 2- Disagree, 3- Neither agree nor disagree, 4- Agree, and 5- Strongly agree).

2.5.3 Pilot Testing of the Instruments

Pilot-testing is a small trial of what is intended to be a large project at a later stage (Tichapondwa, 2013).This is conducted in order to determine whether the methodology, sampling techniques and instruments were working appropriately. The test also helps the researcher to check the clarity of the instructions, lay out and wording of items. Not only has that but also helped the researcher to check if the time allocated to complete the responses is enough. Pilot-testing also assessed for psychometric properties such as item discrimination and item difficulty (Creswell, 2014).

The pilot-testing was conducted on the other two grade eleven classes that didn't take part in the study. This exercise took 2-weeks and there after the pre-test and pre-questionnaire before the intervention was administered, after the intervention the post-test and post-questionnaire was administered as well. The necessary amendments were done to the test items and to questionnaire items, so that the instruments are fine-tuned,

2.6 Validation of research instruments

Both the CAT and ABQ were subjected to peer, chemistry teachers, and expert face validations:

2.6.1 Peer face validation:

After the researcher developed the instruments, gave them to his fellow researchers to look at them and have the instruments validated in terms of clarity of the questions asked, proper wording of the items, appropriateness and adequacy of the question/items to the students level of understanding.

2.6.2 Chemistry teachers face validation:

The research instruments were also given to the Natural Science department for face validation. The instruments was validated in terms of the questions whether they are in line with schemes of work and the syllabus, the topic and sub-topic of the study by chemistry educators or teachers.

2.6.3 Expert face validation:

The instruments were given to the experts in the Faculty of Mathematics and Natural Sciences at the Copper belt University for face validation of the instruments. The instruments were validated in terms of proper wording of the items, appropriateness, and adequacy of the questions/items to the student's level of understanding and experience.

Consequently, the validators made some comments which formed the basis for either modifying or rejecting some of the items. After the validation, the instruments were overhauled completely to reflect the validator's contributions.

2.7 Reliability of the instruments

Reliability is the degree to which an assessment tool produces able and constant results. The idea behind reliability is that any significant results must be more than a one off finding and be inherently repeatable. Other researchers must be able to perform exactly the same experiment under the same conditions and generate the same results (Moskal et al, 2000). The reliability of the instruments was established by carrying out a pilot test on the participants from targeted population of about 100 students, and the scores obtained were analyzed using spss software. Cronbach' s alpha coefficient was used to

measure internal consistency, and it was found that the value of alpha was between 0.70 and 0.865 which simply means that the instruments were reliable.

2.8 Control of extraneous variables

Selection of classes to take part in the study:

In order to avoid biasness, of selecting which classes to take part in the study, out of five grade 11 classes at Temweni Secondary School, the researcher purposively selected four classes out of five classes because they were taking Science (5124), the remaining class was taking chemistry 5070.

The researcher invited four class representatives from the selected classes and conducted a simple random sampling technique by asking these four class representatives to pick a folded piece of paper from a box at the same time and each one was asked to unfold the piece of paper and show it to the group. On these pieces of paper the researcher wrote IN on two of them and OUT on the other two pieces of papers. IN means the class is selected to take part in the study and OUT means the class would not take part in the study. Therefore, those class representatives who picked OUT their classes did not take part in the study and those who picked IN their classes took part in the study.

2.9 Experimental procedure

Procedure:

This study consisted of two (2) phases these were the first phase which is the experimental phase and the second phase in which the Control group was also taught by the researcher using graphic organizers.

In the first week of the study the researcher explained all the possible benefits of the treatment to the participants and all the necessary arrangements were made to see to it that the experiment period would not interrupt the regular class daily routine.

Before the intervention session the participants were given a pre-test and the attitudes and beliefs pre-questionnaire. The pretest and pre-questionnaire was administered by the researcher to both classes taking part in the study. The scripts were taken and marked by the researcher and the scores were recorded. The pretest was used to (1) determine the students initial knowledge of the materials they would learn later,(2) determine the comparability of the two groups(experimental and control groups) with respect to their achievement in the pretest scores and the pre-questionnaire was used to determine the initial feelings and beliefs the students had towards writing and balancing equations.

2.9.1 The Experimental Group:

This group comprised of 51 students of which 16 were boys and 35 were girls. Before the implementation of the treatment, the researcher explained to the subjects the intended purpose of the experiment and its expected benefits for them and explain to them about the concept of graphic organizers and then he divided them into 10 groups each group had 5 members with only one group with 6 members. The main treatment for this study was the teaching of four (4) sub-topics of the topic of Chemical Equations using the two teaching methods (the graphic organizers and Lecture Methods).In the first phase the Experimental group was taught using graphic organizers specifically the Ranking Ladder and Chain of linked events. This lasted for 3 weeks. The figures on appendix G1 shows the researcher showing the two templates of graphic organizers and explain the concepts on how they're going to use GOs to enhance comprehension of chemistry concepts. During this period, participants were allowed to ask questions which were carefully answered by the researcher.

In this same session the researcher explain to the experimental group that since he would be meeting them from 10:20 hours to 11:40 hours, then in the first week the participants would be exposed first to the Ranking ladder organizer and in the second week would be exposed to Chain of linked events.

The researcher gave the participants in their respective groups the following Tips:

A Ranking ladder organizer requires students to place items on rungs of a ladder in order from least to more important, as a group activity it allows students to be challenged as to why they rank one item above the other or below another.

A Ranking ladder provides all students with an opportunity to engage in thinking at the evaluation level of Bloom taxonomy.

This group comprised 60 students from which 35 were boys and 25 were girls. The researcher taught this group with the Lecture method which is one of the conventional methods or common methods teachers uses to teach chemistry in most secondary schools. In this method the researcher verbalized the relevant concepts and principles during the lesson. The students watched and listened attentively and taking down relevant notes. The photo below shows the sitting arrangement in the control group during the lesson

2.9.2 Method of data collection

The data for the study was collected from the pre-test and pre-questionnaire which was administered to the subjects before the start of the learning process, the scores obtained were recorded by the researcher. After phase one of the treatment, post-test1 and post-questionnaire was administered and the scores obtained were recorded by the researcher. At the end of phase two, post-test 2 and 2 weeks after retention-test and post-questionnaire was administered and the scores obtained was recorded by the researcher.

2.9.3 Method of data analysis

The data collected from both instruments that is the pre-test, post-test1,post-test2,retention-test and pre-questionnaire, post-questionnaire were analyzed using a computer program SPSS, which is the statistical package for social sciences.

The researcher used Mean, SD, Frequency tables and Bar chart to provide answers to the research questions. Mean and SD were used because mean is the most reliable measure to central tendency. Also the SD is the most reliable estimate of variability (Nworgu, 1991).

Independent samples t-test was used to test the hypothesis formulated for the study at 0.05 level of significance. Consequently, the null hypothesis is rejected if the value of p is less than 0.05, and if the p-value is greater than 0.05, then the null hypothesis is not rejected.

III. RESULTS OF THE STUDY

3.1 Research Question one

What effect does Graphic Organizers specifically Ranking ladder and Chain of linked events have on student's performance N=111

Table III. Mean of both pre-test andpost-test1 scores.

CAT Means and SD on both pre-test and post-test1						
Groups	Pre-test Mean	SD	Post-test1 Mean	SD	Gain in Mean score	N
Experimental	13.63	10.35	45.20	9.22	31.57	51
Control	14.17	8.14	23.75	15.40	9.58	60
Overall	13.90	9.25	34.48	12.31	20.58	111

As shown in *Table III* above the mean scores of students taught using Graphic Organizers were 13.63 and 45.20 in pre-test and post-test1 respectively, with standard deviation 10.35 and 9.22. On the other hand, the students taught by Lecture method had mean scores of 14.17 and 23.75 and standard deviation of 8.14 and 15.40 respectively in the pre-test and post-test1.

The table also reveal that the experimental group got a mean gain score of 31.57, while the control group had a gain mean score of 9.58. The experimental group differed with the control group in mean CAT gain score by 21.99. This indicates that students taught with GOs achieved higher than students taught with LM.

The standard deviation scores of the students in the pos-ttest1 for the experimental group was 9.22 while for the control group it was 15.40, indicating that the students individual scores were more clustered around the mean with the GOs than with the LM, whose students individual scores were more spread out the mean.

Table III also revealed that the overall mean score for both groups in pre-test was 13.91 and in post-test1 were 34.48. The increase in overall mean score was due to the fact that the other group utilized the GOs. This indicates that GOs had an effect in student performance. The null hypothesis on question one was tested as shown below.

Table IV Mean and standard deviation scores for post-test1and post-test 2.

CAT Means and SD on both post-test1 and post-test2						
Group	Post-test1 Mean	SD	Post-test2 Mean	SD	Gain in Mean score	N
Experimental	45.20	9.22	61.57	8.63	16.37	51
Control	23.75	15.40	59.22	12.37	35.47	60
Overall	34.48	12.31	60.40	10.50	25.92S	111

Table IV in the second phase of the study in which the control group was exposed to the treatment and the initial experimental group was taught with Lecture method, the mean scores of the control group were 23.75 and 59.22 with

standard deviation 15.40 and 12.37 in post-test1 and post-test2 respectively. On the other hand the experimental group had mean scores of 45.20 and 61.57 with standard deviation 9.22 and 8.63 in post-test1 and post-test2 respectively.

The table also reveal that the control group got a mean gain score of 35.47 after being exposed to GOs, while the experimental group had a mean gain score of 16.37. The control group differed in the mean CAT gain score by 19.1. This indicates that the control group performed better after being exposed to GOs, this simply mean that GOs had an effect in the CAT mean scores of the control group than the experimental group which had a small mean gain score when taught with LM. Not only that but also the mean score difference between the experimental group and control group in post-test1 was 21.45, while in post-test2 after the control group was also exposed to the treatment in the second phase and initial experimental group was taught using lecture method, the difference in mean scores reduced to 2.35. The reduction was attributed to the fact that in phase II the control

group was taught using graphic organizers. Therefore, graphic organizers had an impact in the performance of the learners in the control group.

However, the standard deviation scores of the students in the posttest2 for experimental group was 8.63,while their counterparts standard deviation was 12.37, indicating that the students individual scores were more spread out the mean in the control group taught with GOs than the experimental group taught with LM, whose students individual scores were more clustered around the mean.

3.2 Research Question two

What effect does Graphic Organizers have on students' retention mean score of the concepts?

Table V. Mean and standard deviation scores for post-test 2 and retention test

CAT Means and SD on both post-test2 and retention test						
Group	Post-test2 Mean	SD	Retention-test Mean	SD	Gain in Mean score	N
Experimental	61.57	8.63	64.90	8.28	3.33	51
Control	59.22	12.37	60.63	10.54	1.41	60
Overall	60.40	10.50	62.77	9.41	2.37	111

Table V above indicates that the GOs group which is the experimental group obtained means scores of 61.57 and 64.90 in the posttest2 and retention test respectively, with standard deviation of 8.63 and 8.28. On the other hand the LM group meaning the control group obtained mean scores of 59.22 and 60.63 in posttest2 and retention test, with standard deviation of 12.37 and 10.54 respectively. Students in the experimental group had a gain mean score of 3.33, while the students in the control group had a gain mean score of 1.41. The gain score of the experimental group being higher than the control group shows that the experimental group retained higher than the control group.

The table also revealed that the overall mean score of both groups was 60.40 in posttest2 and 62.77 in the retention test, indicating that the increase was attributed to the use of GOs by both groups. This simply shows that GOs had an effect in the retention of students.

3. Research Question three

Does the use of graphic organizers impact the student's attitudes and beliefs towards writing and balancing of chemical equations?

This question was answered by comparing the student's responses on a bar chart for each questionnaire item before and after the treatment. The height of each bar represents the total number of students who responded according to their feelings.

Item 1:

Writing and balancing chemical equations is my favourite sub-topic in chemistry. The responses are shown on bar chart below:

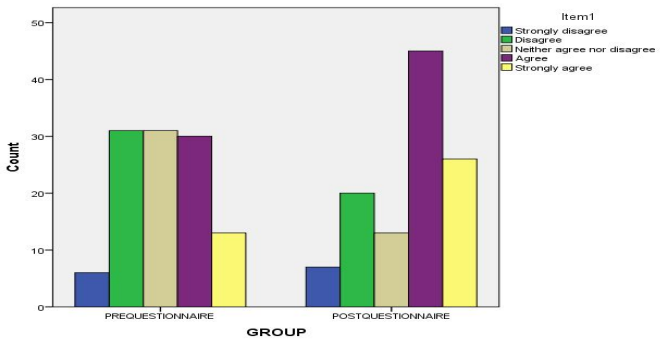


Figure 2.1.Presents the responses of the students on item 1 before and after the treatment.

The figure revealed that after the treatment most of the students agreed that writing and balancing chemical equations was their favourite sub-topic, unlike before the treatment which showed that the students did not understand the concept well and thought the sub-topic was boring.

Figure 3.1.Presents the responses of the students on item 1 before and after the treatment.

The figure revealed that after the treatment most of the students agreed that writing and balancing chemical equations was their favourite sub-topic, unlike before the treatment which showed that the students did not understand the concept well and thought the sub-topic was boring.

Table VI. Summary on how students responded on the pre and post- questionnaires.

	Before The Treatment %		After The Treatment %	
Positive Responses SA + A	1166	27.4	3556	71.0
Neutral Responses NAD	783	18.4	588	11.7
Negative Responses SD + D	2314	54.2	868	17.3

KEY:	positive response	negative response
SA: Strongly Agree	SA = 5	SA = 1
A: Agree	A = 4	A = 2
NAD: Neither Agree nor Disagree	NAD = 3	NAD = 3
D: Disagree	D = 2	D = 4
SD: Strongly Disagree	SD = 5	SD = 1

The table above revealed that the mean percentage score of student's negative responses was *54.2%* higher than *27.4%* for positive responses before the treatment. After the treatment the mean percentage score of student's positive response was *71.0%,* while the negative response mean percentage was *17.3%* respectively. This indicates that after the implementation of the treatment, the attitudes and beliefs of the students changed positively towards writing and balancing of chemical equations. As a result GOs impact the attitudes and beliefs of students positively.

IV. DISCUSSION OF FINDINGS

The discussion of findings is presented under the following inscriptions:-

1. The effect of Graphic Organizers on the mean performance score of the experimental and control groups.

The effect of Graphic Organizers on the mean retention score of the experimental and the control groups.

The effect of Graphic Organizers on student's attitudes and beliefs towards writing and balancing chemical equations.

4.1 The effect of Graphic Organizers (GOs) on the mean performance score of the experimental and control groups.

The result of data analysis on Table revealed that students taught with graphic organizers performed significantly better in chemistry achievement test (CAT) than their counterparts who were taught using the lecture method.

This result is in agreement with the result of earlier studies carried out by Enekwechi (2016), who found in his study that students taught chemistry with advance organizers achieved better and had a higher level of scientific attitude than their counterparts taught with conventional method. The relative superiority of the graphic organizer over the lecture method in enhancing students' achievement in CAT could be attributed to the fact that, as an innovative teaching method, graphic organizer is learner-centred and ensures active participation of students in the learning process more than the lecture method.

The lecture method always subjects the learner to the position of the passive recipient of the facts as handed down to them by the teacher. Moreover, the activities in the GO group were carried out by the learners themselves, at their own pace during the learning period, which is in contrast to the lecture method group where the teacher did most of the work for the students. The active participation of the students involving the use of several sense organs invariably should arouse greater student's interest going by psychological theories (Blair and john Stone, 1975). Given, these prevailing circumstances under which the GOs and LM are employed in the classroom instruction, it is not surprising that the experimental group out- performed the control group in CAT.

4.2 The effect of graphic organizers on the mean retention score of the experimental and control groups.

It has been observed in this study that the Graphic Organizer had a significant effect on student's retention of chemistry concepts learnt. The findings support the similar study done by Day (1990) who asserted that individuals with high need for achievements often are those who are optimistic about the future for its own sake rather than for immediate reward. This means that high achievers are those with very good retention of concepts learnt and can produce them whenever necessary. The results of the study is also in agreement to similar works on innovative methods that aid retention done by Egbugara (1988).Nworgu (1990) and Ezeudu (1995).The results of the study revealed that graphic organizers improved comprehension, which agrees to the saying one scholar that "a picture paints a thousand words", as even the most complicated idea can be broken down into simpler ones by simple illustrations. As effective study guides, graphic organizers provide students with general overview of the topics they study, their patterns and the facts related to the concepts understanding and memorizing. The fact that the GOs helped students to retain more, may be because it is activity-packed and students were allowed to interact with the learning materials promoting meaningful learning and not rote-learning(Wandesee,1990).When the materials learnt are meaningful, they tend to be stored in the long term memory. Hence graphic organizers foster retention due to the fact that the human mind stores and organizes information learned. When ideas are understood it is easily retained in the mind, making it accessible for use when needed. With graphic organizers providing the visuals for a mental storage, remembering is supported and critical thinking skills are developed as sets of retained information are assimilated. As students visualize what was learned, manipulation of ideas that make up the schema is easy. This in turn will aid them in expressing thoughts into words. Spatial learning tools are known to provide opportunities for extracting and remembering information. Graphic organizers are considered a type of scaffolding for learners to establish relationship between what was previously learned and the new materials being studied. Graphic organizers as an innovative teaching technique are considered as tools for understanding information and relationship, they serve as mental tools(Vygotsky,1962) to help the students understood and retain important information's and relationships. They are also considered as tools for organizing information, this simply mean that Human minds organizes and stores information in a series of networks(Ausubel,1968).Graphic organizers are visual depicting that resemble networks and allow students to

add or modify their background knowledge by seeing the connections and contradictions between existing knowledge and new information.

4.3 The effect of graphic organizers on student's attitudes and beliefs in writing and balancing of chemical equations.

From the results obtained on the frequency tables and bar charts for both pre-questionnaire and post-questionnaire, it was observed that the students responded positively, meaning the use of graphic organizers impacted the attitudes and beliefs of students positively towards writing and balancing of chemical equations, these results were in agreement with the study of Oliver(2009) about the effectiveness of concept mapping on students comprehension of science text structure found that students enjoyed concept mapping and would prefer to read and map rather than just read without mapping. The finding was in agreement with Okwo (2002) and Okwo and Tartiyas(2004),also agreed withOkebakola(1990),Ezeudu (1995),Osisioma(1995),Osisioma(2005) and Njoku(2006).One can rightly say that graphic organizers has the ability of arousing, sustaining interest and develop positive attitudes and beliefs towards writing and balancing of chemical equations. Motivating students can best be done through graphic organizers and invite them in meaningful learning.

V .CONCLUSION

Graphic organizers specifically the Ranking Ladder and Chain of linked events were found to be more effective than the Lecture method of student's achievement and retention in the sub-topic of chemical equations in senior secondary chemistry.

The study showed that before the intervention, the mean achievement score of the control group was slightly greater than the experimental group. However the difference between the mean scores was not significant, meaning both groups were at the same level of knowledge. Nevertheless, after the administration of the first post-test, it was revealed that the mean achievement score of the experimental group was much higher than that of their counterparts in the control group. The mean achievement score was significant. This indicated that graphic organizers had an effect on students' performance. When the control group was also exposed to the treatment in the second phase, it was discovered that the mean achievement score of the control group increased than before, though it was slightly less than that of the initial experimental group which was taught with the lecture method in the second phase, the difference was not significant. This indicated that graphic organizers had an effect on the performance of the control group. The mean score difference in post-test1 between the experimental group and the control group was 21.45 in the first phase, after swapping the groups in the second phase, initial experimental group was taught using lecture teaching method and the control group was taught using graphic organizers, the difference between the mean scores was 2.35. This indicated that graphic organizers had an effect on students' performance in writing and balancing of chemical equations.

Table 4.3 indicated that the students were able to retain the concepts, though the mean retention-test score for experimental group was slightly higher than their counterparts the control group. The difference in their mean scores mighty is due to class ability variation, in spite of both groups being exposed to the treatment. The experimental group retained the concepts better than the control group. Therefore, graphic organizers had an effect on student's retention of the concepts of writing and balancing of chemical equations.

The results presented on the bar charts and the frequency table indicated vividly that graphic organizers had impacted the attitudes and beliefs of the students positively towards writing and balancing of chemical equations due to the reason being that before the treatment the percentage reflecting the positive responses was 27.4, while the percentage for negative responses was 54.2. However, after the treatment the percentage for positive responses was 71.0 and the percentage for negative responses was 17.3.

VI RECOMMENDATIONS OF THE STUDY

In respect of the already-mentioned educational implications of the results of this study, the following recommendations are made:-

As the use of graphic organizers has been found effective in improving performance and retention in writing and balancing of chemical equations and that the teaching method is relatively new in Zambia, it should be included in the science curriculum of Teachers' Training tertiary Colleges and Universities, so as to popularize its use among the teachers and hence bring about more effective learning of chemistry in our secondary schools.

In view of the established efficacy of graphic organizers and the fact that most of the serving teachers or educators may not be familiar with its use, seminars and workshops should be organized by the ministry of general education of Zambia and relevant professional bodies such as Zambia association for science educators (ZASE) to educate and sensitize the teachers on the use of graphic organizers in the teaching and learning process.

Government agencies and professional associations whose responsibility is to design and revise the curriculum for secondary schools should incorporate and emphasize the use of graphic organizer teaching method in the teaching of chemistry and other science subjects.

In respect to the results of this study, it can be deduced that graphic organizers are effective innovative method of instruction, as a result, they can be used as a supplement to other learner-centred methods such as question and answer method to mention but a few.

VII. SUGGESTIONS FOR FURTHER RESEARCH

The following areas of further research are suggested in line with the findings of this study:-

Research should be carried out in other perceived complex and challenging topics in chemistry such as mole concept and organic chemistry.

The study should be replicated in other science subjects such as Physics, Biology, and Mathematics.

There are several types of graphic organizers; therefore further studies can be conducted on them as individualized instructional methods, such as stair steps, Fish born and many more.

Similar studies can be replicated using a wider geographical area.

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