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The Effect of Procedural Knowledge Instructional Technique and Graphic Organisers on Chemistry Students' Academic Achievement in Writing and Balancing of Chemical Equations

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Abstract

This study investigated the effects of procedural knowledge instructional technique and graphic organisers on chemistry students' academic achievement in writing and balancing of chemical equations. Two research questions and two hypothesis guided the study The study adopted quasi-experimental research design. The population of this study consists of all the 5,328 SS1 students (1922 males and 3,406 females) in all the 32 public secondary schools in Enugu Education Zone, A sample size of 180 SS1 students was used for the study gotten using multistage sampling procedure. The instrument used for data collection was:Writing and Balancing of Chemical Equations Achievement Test (WBCEAT) and the lesson plans. The instrument was developed by the researcher. The instrument and the lesson plans were given to three experts for face validation. The reliability of the instrument was determined using Kudder-Richardson Formula 20 (K-20) and the reliability index of WBCEAT is 0.73. The high coefficient estimate value revealed that the instrument is reliable. The data collected were analysed using mean and standard deviation to answer the research questions, while the hypotheses were tested at a 0.05 level of significance using Analysis of Covariance (ANCOVA). The result of the findings revealed that there is a significant difference in the mean achievement scores of Chemistry students taught writing and balancing of chemical equations using procedural knowledge instructional technique and those taught using graphic organisers in favour of the Chemistry students taught using graphic organisers. Also, there is no significant difference in the mean achievement scores of male and female Chemistry students in writing and balancing of chemical equations.

Key words: Procedural knowledge, Graphic organizer ,Chemistry, Academic Achievement, Chemical Equations

Introduction

Chemistry occupies an important space in the economic and technological development of any nation. Its roles in both national and global development are numerous. The study of Chemistry develops in one the ability to understand some of the occurrences within one's environment and also acquaint one with skills for solving problems within the locality. Chemistry is one of the pure sciences that deals with the chemical aspect of nature. It is the study of matter which offers information on the structure of matter, how matter combines to form new substances, as well as the necessary conditions that aid the production of such new substances. Chemistry, as defined by Rocke and Usselman (2023), is the science that deals with the properties, composition, and structure of substances (defined as elements and compounds), the transformations they undergo, and the energy that is released or absorbed during these processes. Chemistry, as a school subject, is relevant to a number of manufacturing industries such as pharmaceutical, food processing, agriculture, clothing and textiles, petrochemical and metallurgical. This shows that Chemistry, as a subject, has immeasurable utility values and permeates different areas of national economy. It is, therefore,imperative that the study of Chemistry plays a vital role in the technological transformation of any nation as it has the capacity of aiding to solve the problems of increasing unemployment and high poverty rates.

Despite all this importance of Chemistry, it has been observed by some researchers that students still find the study of the subject difficult, leading to poor academic achievement (Eya, 2011; Idah et al., 2016). Cardellini (2012) noted that sources of students' difficulties can have at least three origins:which includes the abstract nature of Chemistry, method of teaching Chemistry, and special language of Chemistry.The author also stressed that the specialist language that chemists use can be a barrier to understanding Chemistry because communication in Chemistry is in a highly elaborated alphabetic and symbolic language. One reason why so many students find Chemistry difficult is the abstract nature of the concepts. They are abstract because some of the processes are practically not observable. The great challenge is the development of a coherent explanation of the complex behaviour of reaction processes, the interaction between substances, leading to the formation of new substances and the destruction of old ones. It is therefore important that the teaching of these concepts in Chemistry be improved by employing innovative techniques which will enhance better understanding of the concepts.

In the study of Chemistry, there are some topics that are identified as difficult to understand by students. Some of such topics are mole concepts, electrolysis, organic chemistry, balancing of chemical equations, etc. (Attah & Njoku, 2018). Nwoji (2022) also identified the concept of writing chemical formulae of molecules and compounds as one of the difficult areas in Chemistry and this is attributed to the poor knowledge of the rules involved. Ekere (2014) also reported that candidates have difficulty in writing and balancing of chemical equations. Dula (2018) reported that Chemistry students often have great difficulties in both acquiring and using the skills required to balance chemical equations. This difficulty encountered by the students

could be as a result of the students not making sense of the invisible and untouchable chemical reactions that the chemical equation expresses. This when addressed by using the appropriate instructional approaches, will aid in improving the performance of the students in the concept of chemical equation.

Chemical equation is one of the most important concepts in the learning of science, particularly Chemistry. To know the reactions, the students should have a sound approach to writing and balancing chemical equations. Chemical equation entails the usage of symbols and formulae in the description of chemical reactions (Arzoo, 2020). It is a short way to show a chemical reaction using symbols instead of words. According to Ojokuku (2012), a chemical equation is a shorthand method of using chemical formulae to present a chemical or physical change. It is a statement in a formula that shows the relative number of moles of particles involved in a chemical reaction; Chemical Equations provide us with the state of the reacting species and products i.e., whether they are in liquid, solid or gaseous state or in solution (aqueous). It sometimes provides information such as heat loss and gain (Makwana, 2022). This information from chemical equations helps in understanding the chemical processes or reactions that the chemical equation tends to express.

The writing and balancing of chemical equations is in accordance with the law of conservation of mass (matter), which states that matter cannot be created nor destroyed during chemical reactions. The number of atoms of elements on each side of the equation are same. In writing and balancing of chemical equations, the exact numbers of kinds of molecules involved as well as their ratios are shown. According to Zabadi and Assaf (2017), a chemical equation is balanced if the numerical strength of each atom is equal at both sides of the equation. In other words, chemical equations give details about the quantity of reactants used and corresponding yield of the products. The importance of writing and balancing of chemical equations is greatly felt in the industries

Writing and balancing chemical equations is a very important topic for any student studying or intending to study Chemistry. This, notwithstanding, it is often reported as a difficult and abstract concept (Yakmaci-Guzel, 2013). It is so because the students cannot visualize chemical reactions. In the school curriculum,in Nigeria, this topic falls within the first year of the senior secondary level (Federal Ministry of Education [FME], 2009) and as such, forms part of the foundation upon which Chemistry education is laid. This stands to show its importance in the building of chemical knowledge in a learner. Without the mastery of this concept, it is difficult for students to progress in learning higher-level Chemistry. The numerous benefits inherent in the information provided by chemical equations require that students should maintain a high level of academic achievement in the concept.

Academic achievement could be said to be the extent to which students have achieved set educational goals. Academic achievements are the successful completion of tasks through the effort of the acquisition of academic content and skills which is determined by the scores or

grades that students get in an examination or test (Mutua, 2015).. The poor achievement of students in Chemistry as a whole and in writing and balancing of chemical equations have been reported over the years. Achor and Ukwuru (2014) reported poor academic achievements of students in some essential topics, particularly concepts such as the equilibrium of chemical reactions, moles, the writing of chemical formulae and writing and balancing of chemical equations and undertaking calculations from them. In 2018 and 2019, the WAEC Chief Examiners suggested, among other things, that students should learn how to write and balance chemical equations correctly. This is to ensure improvement in students' ability to write and balance chemical equations which will subsequently aid better performance in this area.

The issue of poor academic achievement of students in writing and balancing of chemical equations has been of great concern to both teachers and researchers because,without the mastery of this concept, Chemistry education is bound to be a failure. Some researchers have revealed in their studies the possible causes of these students' poor academic achievement in Chemistry, particularly the writing and balancing of chemical equations. Shadreck and Enunuwe (2018) summarised the causes of poor achievement in the writing and balancing of chemical equations to include lack of understanding of mole concepts, inability to balance chemical equations, and use of inconsistent stochiometric relationships, among others. This shows that the root of the problem may be attributed to poor instructional approach.

Poor instructional approaches do not support students' active participation in the learning process. Enekwechi (2016) pointed out that the type of instructional plan used by teachers determines how effective learning can be. The author stressed that poor teaching would lead to poor learning and achievement. According to Sukolatambaya (2018), one of the responsibilities of a teacher is the ability to use appropriate instructional strategies in teaching. Instructional techniques, in which learners are actively involved would likely lead to meaningful learning and not rote learning (Enekwechi, 2016). Examples of such instructional techniques include procedural knowledge and graphic organisers. Therefore, there is a need to look closely at the ways Chemistry, particularly writing and balancing of chemical equations could be taught in schools in order to improve students' performance. This prompted this research on the effect of procedural knowledge instructional technique (PKIT) on the academic achievements of students in the writing and balancing of chemical equations. The researcher's choice of this technique is based on its ability to stipulate and acquaint the learner with the rules, steps, or actions needed to accomplish a task. In order words, the learner is not left in doubt of what to do to attain success in a set task. Also, the emphasis on the usage of learner-centred instructional approaches creates room for this technique since the teacher only acts as a facilitator.

Procedural knowledge involves the application of steps, rules or guidelines in accomplishing a task to a desired standard. Procedural knowledge is one of the knowledges that is needed to understand concepts and develop problem solutions by employing appropriate procedures (Yilmaz, 2020). Procedural knowledge is the knowledge of working procedures steps

and how to solve problems according to these steps (Wuryaningrum et al., 2020). Procedural knowledge can be defined as knowledge that includes sequential action steps and the application of automated techniques to solve problems standard (Nwoji & Njoku, 2018).. Sacks et al. further penned that in the classroom, procedural knowledge is what is learned about the learning process – learning skills and strategies. Carl (2014) asserted that procedural knowledge (also known as knowing how and sometimes referred to as practical knowledge, imperative knowledge or performative knowledge) is the knowledge exercised in the performance of some tasks. Procedural knowledge usually needs time and practice to master unlike declarative knowledge that can be learned rapidly/ The knowledge can only be obtained through constant practice. Procedural knowledge can focus on following sequential action towards achieving a specific objective or an end goal (Moraks & Arith, 2021). The authors further asserted that the best way to display procedural knowledge is through giving demonstrations or coaching by delivering step-by-step instructions. Procedural knowledge instructional technique involves assisting individuals to acquire skills and knowledge so that they are able to perform a task to a specific standard (Nwoji & Njoku, 2018).

Some research works on Procedural Knowledge Instructional Technique have proved the technique to be efficient in teaching and learning. The study of Syaiful (2023) in problem-solving models using procedural knowledge in solving Mathematics revealed that mathematical problem-solving using procedural knowledge significantly improved learning outcomes. Similarly, van der Eem's (2021) study on students' evaluation of the trusted worthiness of historical sources (procedural knowledge and task value as predictors of students' performance) showed that both procedural knowledge and task value are significant predictors of task performance. Having ascertained that PKIT was potent in improving the performance of students in the aforementioned areas and that literature is not replete with the use of PKIT in teaching Chemistry, this therefore creates the need for this study. Apart from procedural knowledge instructional technique, graphic organisers (GO) is also another technique that can aid in improving academic achievement of students in the writing and balancing of chemical equations.

Graphic organisers (GO) are used as a teaching resource that engages students in analysing the relationships between concepts and ideas. Graphic organisers are visual and graphic displays that depict how facts, terms and/or ideas within a learning task are related (Lynch, 2021). Bishop (2013) defined graphic organisers as visual displays of key content information designed to guide students and enhance their comprehension. Graphic organisers are non-linguistic, visual tools that enable learners to nect new information to their existing knowledge and see how concepts relate to each other and fit in, which in turn makes them recall information easily (Chanshi & Daka, 2020). According to Chanshi and Daka, in graphic organisers, learning materials are broken down into small steps that are arranged sequentially from known to unknown and in increasing order of difficulty or complexity. Graphic organisers integrate texts and visuals, and this has been scientifically proven to be an effective way of

teaching. According to Athuraliya (2020), graphic organisers can be used in all grade levels. They are designed to improve learning outcomes for students, review information and are especially helpful to students who struggle with arranging information . Cox (2020) stated that a graphic organiser is a powerful visual learning tool that teachers use to help students organise their ideas. Cox stressed that graphic organisers can also be used to clarify or simplify complex concepts, help with problem-solving or decision-making, or be used to plan research or brainstorm ideas. Graphic organisers provide a visual and holistic representation of facts and concepts and their relationship within an organised frame (Enekwechi, 2016). According to Kroll (2021), how graphic organisers are used depends on the objective and some organisers can be used for more than one purpose. Graphic organisers can exist in many forms like flowcharts, story maps, Venn diagrams, t-charts, concept maps, sequence of event chains, time-line charts, etc. (Velarde, 2019).

The forms of graphic organisers that will be used in this study include Venn diagrams (use of overlapping circles to illustrate the logical relationship between two or more sets of items), ranking ladders (used to prioritize and rank ideas/information) and organised pictorials (a collection or presentation of visual images arranged in a structured or systematic manner for a specific purpose). This will aid in showing relationships between facts and ideas, sequence information and colour-code items. Graphic organisers are often used as prompts for students to construct ideas, organise and sequence information, plan what to write, increase reading comprehension, brainstorm, organise problems and solutions, compare and contrast ideas, show cause and effects and more (Lynch, 2021). According toLynch, the ability to colour-code thoughts in a picture can help significantly in understanding and retaining the information. With graphic organisers, teachers can create learning activities that are engaging, interactive and meaningful. The potential ability of graphic organisers in teaching is the ability to help students learn through the use of visual aids. Also, studying the concept of writing and balancing of chemical equations with graphic organisers will give students the opportunity of arranging what is learned in a sequential manner and creating relationships between ideas. This study aims to investigate the effects of graphic organisers on students' academic achievement and in writing and balancing of chemical equations.

Positive outcomes have been reported by some researchers who have integrated graphic organisers in their different fields of study... Literature is replete with the effects of GO in many studies but few in writing and balancing of chemical equations. It then becomes imperative to examine what effects teaching and learning of writing and balancing of chemical equations with GO will have on Chemistry students' academic achievement. Students' academic achievement could be influenced by the learning environment, mental ability level or gender. Gender includes norms, roles, and relationships associated with being male or female which is being assigned by the society. Gender is defined as the socially constructed roles, behaviour, and attributes that a society considers appropriate for men and women (Newman, 2021). Gender is the state of being

male or female in relation to the social and cultural rules that are considered appropriate for men and women. Researchers have conducted several studies on gender in a bid to find out if gender really influences achievement in Chemistry.

Some of these studies show that there is an influence of gender on achievement and while others do not.. Based on the facts above, it is evident that gender influence on academic achievements and retention in Chemistry is still inconclusive. These contradictions in the findings call for further clarifications and has prompted this study so as to add to the body of literature by ascertaining whether gender has an influence on the academic achievement of students in writing and balancing of chemical equations. Thus, the problem of this study posed in question form, is: what are the effects of procedural knowledge instructional techniques and graphic organisers on students' achievement in writing and balancing of chemical equations? The study's purpose is to determine the effects of procedural knowledge instructional technique and graphic organisers on Chemistry students' academic achievements in writing and balancing of chemical equations. The following research questions guided the study:

1. What are the mean achievement scores of Chemistry students taught writing and balancing of chemical equations using procedural knowledge instructional technique and those taught using graphic organisers?
2. What are the mean achievement scores of male and female Chemistry students in writing and balancing of chemical equations when
3. What is the interaction effect of the instructional techniques and gender on Chemistry students' mean achievement scores in writing and balancing of chemical equations?

Research Methods

The design of this study is quasi-experimental; specifically, pre-test, post-test group design. Quasi-experimental design according to Nworgu (2015), does not allow for randomization of subjects, but for random assignment of intact class to treatment and control groups. This design was opted for the study because it is not possible to have randomly assigned subjects, rather, intact classes were used to enable the researcher to compare outcomes from different groups partaking in the study. This study was carried out in Enugu Education Zone of Enugu State.. Enugu Education Zone is located in the eastern part of Enugu State. It consists of three (3) local government areas, namely: Enugu East, Enugu North and Isi-Uzo, which are predominantly Igbo-speaking people. Furthermore, there tends to be poor enrolment of students who offer Chemistry in SS2 and SS3 as compared to other science subjects... The reason for this might be due to poor understanding of the fundamental concepts in Chemistry due to inappropriate instructional approaches. It is based on this that the researcher seeks to embark on this study.

The population of this study consists of all 5,328 SS1 students in all the 32 public secondary schools in Enugu Education Zone, consisting of 21 co-educational schools and 11 single-sex schools. This population is made up of 1922 males and 3,406 females. The sample

size for the study is180 SS1 students. For the purpose of this study, multistage sampling procedure is employed. Firstly, two local government areas out of the three local government areas in Enugu Education Zone were sampled using simple random sampling through balloting without replacement. Simple random sampling through balloting without replacement was also used to sample four co-educational public secondary schools out of the nine co-educational public secondary schools in both Enugu East and Enugu North L.G.As (two from each LGA) of the Enugu Educational Zone.Finally, one intact class of SS1 students was sampled from each of the four co-educational public secondary schools using simple random sampling through balloting without replacement, thus giving a total of four intact classes for the study.Using the same sampling technique, two of the intact classes were assigned to experimental group 1 (Procedural Knowledge Instructional Technique), while the other two were assigned to experimental group 2(Graphic Organizers).

The instrument used for data collection was:Writing and Balancing of Chemical Equations Achievement Test (WBCEAT) and the lesson plans. The instrument was developed by the researcher.The items for the WBCEAT were 30 questions drawn from the West African Senior School Certificate Examination (WASSCE) past questions and approved Chemistry textbooks.A test blueprint was developed to assist in assigning of weights to topics . The WBCEAT has two sections. Section A sought information on demographic data, such as gender and school, while Section B consisted of 30 objective questions on writing and balancing of chemical equations with four options (A, B, C, and D) in which the students were expected to choose one correct answer. In scoring the objective test, each of the questions carried one mark, giving a total of 30 marks...

The instrument (WBCEAT) and the lesson plans were given to three experts for face validation. The face validation of the instrument was carried out by three experts in the Department of Science Education Faculty of Education, University of Nigeria, Nsukka..Also, to ensure the content validity of the instrument, a test blueprint was developed by the researcher. The recommendations (reconstructing of some questions and removal of some questions that seem vague) made by the experts were used in rephrasing some of the items and incorporated into the final version of the instruments.

To determine the reliability of the instrument, the instrument was trial-tested by administering it on 20 students drawn from a secondary school in Enugu North LGA, which is not part of the sample.The data collected was analysed using Kudder-Richardson Formula 20 (K-20) to determine the internal consistency of the instrument (WBCEAT). K-20 was used because the instrument was dichotomously scored. The reliability index of WBCEAT is 0.73. The high coefficient estimate value revealed that the instrument is reliable and can be used for the study.

Experimental Procedures

The researcher obtained a letter of identification from the Head of Department in the Department of Science Education which enabled the researcher to gain permission from the principals of the sample schools who in turn introduced the researcher to the SS1 Chemistry teachers who served as the research assistants. The period for the experimental work lasted for seven weeks. The training of the research assistants commenced one week prior to the actual teaching and lasted for four days.

Day 1

This day was for the introduction and familiarization of the researcher and the Chemistry teachers (research assistants).

Day 2

This day was for discussions on chemical equations and how it is being taught. Also, the researcher educated the research assistants for experimental group 1 on the necessary techniques for teaching students with Procedural Knowledge Instructional Technique.

Day 3

The researcher acquainted the research assistants for experimental group 2 with the necessary techniques required for teaching students with Graphic Organizers. During the course of the training on Days 2 and 3, the researcher took time to explain in detail all the stages involved in the research work.The lesson notes developed by the researcher was given to the research assistants for them to take home and study.

Day 4

At the end of the training, the research assistants in each experimental group conducted mini-mock teaching to allow the teacherswho served as research assistants to demonstrate the teaching techniques and alsofor the researcher to check for their competence in the different techniques before the commencement of the actual teaching.

The actual teaching lasted for three (3) weeks. The pre-test (WBCEAT) was administered in the class for forty (40) minutes by the research assistants who are the classroom teachers in the sampled schools. The instructions on how the students will answer the questions was clearly written on the instrument and further emphasised by the research assistants. The students were assured of the confidentiality of the information given out by them. The answer scripts used in answering the test were collected immediately after the completion of the test.

On completion of the pre-test, the treatment programme was conducted in the four classes by the research assistants for the period of three weeks. The contact was one session of 80 minutes, once a week.

In the first week, the research assistants used the different techniques assigned to them in teaching the students the topic, “Elements and their symbols,” in their respective groups. The students were introduced to the identification of the first 20 elements of the Periodic Table, their symbols, and how the symbols were derived. In the second week, the students were taught

writing of formulae of compounds from their valences, using the different techniques in their respective experimental groups. The students were introduced to drawing of the structures of the atoms of the first 20 elements of the Periodic Table, writing their valences, rules guiding the writing of formulae, and writing of formulae. In the third week, the students were exposed to writing and balancing of chemical equations by acquainting them with the rules guiding the writing and balancing of chemical equations. After the treatment session, a post-test was administered. The responses of the students were scored, and the scores were compared with their pre-test scores. The results were analysed for this study.

The data collected were analysed using the following statistical tools: mean and standard deviation were used to answer the research questions, while the hypotheses were tested at a 0.05 level of significance using Analysis of Covariance (ANCOVA). The pre-test scores were used as covariates to the post-test scores. If the exact probability associated with the calculated value of the test-statistics is less than 0.05 level of significance, the null hypotheses (H_o) will be rejected, otherwise, it will not be rejected.

Results

Table 1 shows that the mean achievement scores of the Chemistry students taught writing and balancing of chemical equations using procedural knowledge instructional technique at the pre-test and post-test are (M = 11.22, SD = 3.14) and (M = 17.76, SD = 3.95) respectively. On the other hand, the mean achievement scores of the Chemistry students taught writing and balancing of chemical equations using graphic organisers instructional technique at the pre-test and post-test are (M = 11.16, SD = 3.12) and (M = 19.32, SD = 3.66) respectively. Thus, the adjusted means of 17.72 and 19.34 for the Chemistry students taught writing and balancing of chemical equations using procedural knowledge instructional technique and those taught using graphic organisers respectively indicate that the Chemistry students taught writing and balancing of chemical equations using graphic organisersinstructional technique had higher post-test mean achievement score than their counterparts taught using procedural knowledge instructional technique. Besides, the post-test standard deviations of 3.95 and 3.66 for the two groups respectively, imply that the individual achievement scores of the chemistry students taught using procedural knowledge instructional technique varied widely from their group mean than those taught using graphic organisers.

Table 1: Mean analysis of the achievement scores of Chemistry students taught writing and balancing of chemical equations using procedural knowledge instructional technique and those taught using graphic organisers

		Pre-test			Post-test		Adjusted Mean
Group		N	Mean	Std. Deviation	Mean	Std. Deviation	
Procedural Technique	Knowledge	78	11.22	3.14	17.76	3.95	17.72
Graphic Organizer		76	11.16	3.12	19.32	3.66	19.34

Table 2 reveals that there is a significant difference in the mean achievement scores of Chemistry students taught writing and balancing of chemical equations using procedural knowledge instructional technique and those taught using graphic organisers in favour of the Chemistry students taught using graphic organisers, F (1, 149) = 6.764, p = 0.010. Since the associated probability value of 0.010 is less than the 0.05 level of significance, the null hypothesis is rejected. Moreover, the effect size (Partial Eta Squared) value of 0.043 indicates that 4.3% increase in the achievement of Chemistry students in writing and balancing of chemical equations is attributed to the effect of graphic organisers.

Table 2: Analysis of covariance for the effect of instructional technique on Chemistry students' achievement in writing and balancing of chemical equations

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	112.419[a]	4	28.105	1.917	0.110	0.049
Intercept	3628.851	1	3628.851	247.575	0.000	0.624
Pretest	0.377	1	0.377	0.026	0.873	0.000
Treatment	99.140	1	99.140	6.764	0.010	0.043
Gender	3.768	1	3.768	0.257	0.613	0.002
Treatment * Gender	13.556	1	13.556	0.925	0.338	0.006
Error	2183.977	149	14.658			
Total	55151.000	154				
Corrected Total	2296.396	153				

Table 3 shows that the mean achievement scores of the male Chemistry students in writing and balancing of chemical equations at the pre-test and post-test are (M = 10.57, SD = 3.55) and (M = 18.29, SD = 3.71) respectively. On the other hand, the mean achievement scores of the female Chemistry students in writing and balancing of chemical equations at the pre-test and post-test are (M = 11.67, SD = 2.64) and (M = 18.71, SD = 4.01) respectively. Thus, the adjusted means of 18.37 and 18.69 for the male and female Chemistry students in writing and balancing of chemical equations respectively indicate that the female Chemistry students had higher post-test

mean achievement score than the male Chemistry students. However, the post-test standard deviations of 3.71 and 4.01 for the male and female Chemistry students respectively, imply that the individual achievement scores of the female Chemistry students varied widely from their group mean than those of the male Chemistry students.

Table 3: Mean analysis of the achievement scores of male and female Chemistry students in writing and balancing of chemical equations

	Pre-test			Post-test		Adjusted Mean
Gender	N	Mean	Std. Deviation	Mean	Std. Deviation	
Male	68	10.57	3.55	18.29	3.71	18.37
Female	86	11.67	2.64	18.71	4.01	18.69

Table 2 reveals that there is no significant difference in the mean achievement scores of male and female Chemistry students in writing and balancing of chemical equations, F (1, 149) = 0.257, p = 0.613. Thus, the null hypothesis is not rejected since the associated probability value of 0.613 is greater than the 0.05level of significance. This implies that gender had no influence on the achievement of Chemistry students in writing and balancing of chemical equations...

Table 4 shows that male Chemistry students who were taught writing and balancing of chemical equations using procedural knowledge instructional technique had post-test mean achievement score of (M = 17.25, SD = 3.27) while the female Chemistry students who were taught writing and balancing of chemical equations using procedural knowledge instructional technique had post-test mean achievement score of (M = 18.19, SD = 4.44). Similarly, the male Chemistry students who were taught writing and balancing of chemical equations using graphic organisers instructional technique had post-test mean achievement score of (M = 19.47, SD = 3.88) while the female Chemistry students who were taught writing and balancing of chemical equations using graphic organisers instructional technique had post-test mean achievement score of (M = 19.20, SD = 3.53). This indicates that while female students of the procedural knowledge group had higher post-test mean achievement than the male students of the same group, the male students of the graphic organisers group had higher post-test mean achievement than the female students of the same group.

Table 4: Mean analysis of the post-test achievement scores of male and female Chemistry students taught writing and balancing of chemical equations

Treatment	N	Gender	Mean	Std. Deviation
Procedural Knowledge	36	Male	17.25	3.27
Technique	42	Female	18.19	4.44
Graphic Organizer	32	Male	19.47	3.88
	44	Female	19.20	3.53

Table 2 reveals that there is no significant interaction effect of the instructional technique and gender on the mean achievement scores of Chemistry students in writing and balancing of chemical equations, F (1, 149) = 0.925, p = 0.338. Thus, the null hypothesis is not rejected since the associated probability value of 0.338 is greater than the 0.05 level of significance. This implies that Chemistry students' achievement in writing and balancing of chemical equationsas a result of their exposure to different instructional techniques is not dependent on their gender

Discussion

The result of the study showed that Procedural Knowledge Instructional Technique (PKIT) and Graphic Organisers (GO) had positive effects on students who were taught writing and balancing of chemical equations. However, it was further revealed that there is a significant difference in the mean achievement scores of Chemistry students taught writing and balancing of chemical equations using Procedural Knowledge Instructional Technique (PKIT) and those taught using Graphic Organisers (GO) in favour of the Chemistry students taught using Graphic Organisers (GO). The result indicates that students' ability to write and balance chemical equations is better when taught using GO than when taught using PKIT. This finding therefore suggests that the use of GO is more efficacious than the use of PKIT. The reason for this finding might be that GO always establishes relationships between prior knowledge and new concepts which invariably makes for more meaningful understanding of the concepts taught. Also, because the strategy makes for visualisation of the concepts, it tries to reduce the abstract nature of the concept of chemical equations thereby improving students' academic achievement. This finding agrees with the research findings of Kaur and Kamini (2018) and Opara and Lami (2020) which revealed that students taught using GO had significant improvement in their academic achievement.

The result of the study also showed that there is no significant difference in the mean achievement scores of male and female Chemistry students in writing and balancing of chemical equations. This implies that gender had no significant influence on the academic achievement of Chemistry students in writing and balancing of chemical equations. This is an indication that the male and female Chemistry students responded effectively to treatment irrespective of the gender. Perhaps, this is because GO integrates text and visuals to both males and females equally and that might be why there was no significant difference in their academic achievement. This finding agrees with the findings of Chabari et al. (2018) and Opara and Lami (2020) which revealed that there was no significant difference in the achievement of male and female students when taught using GO. The implication of the finding of this study is that GO will aid in the delivery of instruction to both males and females so as to attain improved academic achievement.

The result of the study also reveals that there is no significant interaction effect of the instructional techniques and gender on the mean achievement scores of Chemistry students in writing and balancing of chemical equations. This implies that Chemistry students' achievement in writing and balancing of chemical equations as a result of their exposure to different

instructional techniques is not dependent on their gender. The finding is in agreement with the result obtained by Mihindo et al. (2017) which showed that interaction effect of instructional approaches with gender on students' achievement in Chemistry was not significant. Contrarily, the study of Agboghoroma (2015) revealed a significant interaction effect of instructional approach with gender on students academic achievement in basic science.

Conclusion

Graphic Organisers (GO) are more effective than Procedural Knowledge Instructional Technique (PKIT) in teaching writing and balancing of chemical equations in Chemistry as it was found to improve both academic achievement and retention among Chemistry students. Also, gender has no significant influence on the Chemistry students' academic achievement in writing and balancing of chemical equations. Graphic Organisers should be adopted by Chemistry teachers for teaching writing and balancing of chemical equations and probably some other abstract concepts in Chemistry in secondary schools. The use of Graphic Organisers (GO) in teaching is time-consuming and as such, more time should be allotted to their use in the school timetable.

Implications of the Findings

The findings of this study have educational implications for students, Chemistry teachers, curriculum planners, and the government. The finding of the study implies that teachers should adopt learner-centred approaches like procedurial knowledge and advanced organizers in teaching those topics tagged "abstract," as it makes it simpler and concrete and, as such, enhances academic achievement. For the curriculum planners, the findings will guide them in the planning and development of the curriculum, as well as creating awareness of these instructional approaches to teachers through the addition of such in the curriculum and emphasising on its implementation by teachers in teaching abstract and difficult concepts in Chemistry. For the government, the findings will inform them on the necessary human and financial resources to be provided for the execution of these teaching approaches.

Limitations and further direction

In as much as the results of this study revealed improvement in the academic achievement of Chemistry students in writing and balancing of chemical equations, the study has some limitations. In the course of the experimental section, there is the possibility of the students copying answers from each other, thereby reducing the authenticity of the scores gotten. Also, individual differences among the research assistants which is bound to play out during the teaching section can constitute a source of limitation to this study. Replicating the study in other areas of Chemistry that are identified as abstract and difficult, for example, electrolysis, organic Chemistry, etc. Investigating and ascertaining teachers' attitude towards the use of Graphic Organisers (GO) in facilitating the teaching and learning process in the classroom

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