UNIVERSITY OF EDUCATION, WINNEBA

FACULTY OF SCIENCE EDUCATION

THE EFFECT OF USING MOLECULAR MODELS IN TEACHING ON THE PERFORMANCE OF SHS STUDENTS IN NAMING OF ORGANIC COMPOUNDS.

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DISSERTATION IN THE DEPARTMENT OF SCIENCE EDUCATION, FACULTY OF SCIENCE EDUCATION, SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES, UNIVERSITY OF EDUCATION, WINNEBA IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE MASTER OF SCIENCE EDUCATION DEGREE.

DECEMBER, 2015

DECLARATION

CANDIDATE'S DECLARATION

I, **Gershon Kwaku Wosor,** hereby declare that apart from references to other people's work which has been duly cited and acknowledged, this Action Research is as a result of my own work and neither in whole nor part has be presented elsewhere.

Candidate's Signature: ………………………………….

Date: ……………………………………………….…

SUPERVISORS' DECLARATION

I, **Prof. John K. Eminah,** hereby declare that the preparation and presentation of the dissertation was supervised in accordance with the guidelines of dissertation laid down by the University of Education, Winneba.

Supervisor's Signature: …………………………….………....

Date: ………………………………………………….….

DEDICATION

To God the father, the Son and the Holy Spirit. I am also not forgetting my wife, Felicia Lebene Kpekpena and son, Justice AblordeWosor.

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ABSTRACT

This study investigated the problems SHS Chemistry students faced in naming organic compounds especially hydrocarbons by IUPAC rules at Zion College Senior High School in the Keta Municipality. The research work established if there was a significant difference between the performance of students taught by the traditional method and those taught using molecular models. It also considered whether if there was significant difference between the performance of boys and girls in the experimental class after the intervention. A total of 98 SHS2 chemistry students were targeted. Only 86 students took part in the research. After tossing, the science classes A and B became control and experimental class respectively. Both classes were taught with the same traditional method of teaching and a pretest was conducted. It was then followed with the intervention, that is teaching the experimental class using molecular model and the control class taught with the traditional method. Posttest was conducted and the results were collected after marking. The data collected were analyzed using frequency count, percentages and t-test. Statistically, the calculated $P(T<=t)$ is 0.095 which is greater than the alpha value 0.05 implying that there is no significant difference between the performance of elective chemistry students taught with the traditional method and students taught using molecular models. In the light of this analysis therefore, the researcher failed to reject the first null hypothesis (H_o *1*).In comparing the performance of boys and girls in the experimental class in the posttest, the researcher reject the second null hypothesis (H_o *2*) formulated for the study. This is because the calculated $P(T<=t)$ 0.034 is less than the alpha value 0.05.

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INTRODUCTION

1.2 Overview

This chapter discussed the background to the study, statement of the problem, Purpose of the study and objectives of the study. The research questions, significance of the study, limitations and delimitations are also presented in this chapter.

1.2 Background to the Study

Students accommodate the same information in different ways. This is because students come to class with prior knowledge and certain experiences about the subject matter. These experiences can either facilitate acquiring of new concept or rather inhibit acquiring new information. Whether the new information will be well accommodated or not depends upon how the information is presented by the teacher. If information is carefully presented in a manner in which students think and learn, it will minimize misconceptions and provide room for innovation and creativity.

Educators can only know if the students acquire what they are teaching by the output of the student. Bruner says learner must be active participant in the learning process. This is the reason why teachers should incorporate different formats and models in to teaching the subject matter of a lesson so that learners can discover the true understanding for themselves. This is what we call insightful learning. Insightful learning paves way for useful application of information which leads to innovation.

For many decades science educators and researchers all over the world have explored ways to help students develop a true conceptual understanding of chemical representations (Ben-

Zvi, Eylon, & Silberstein, 1986). In understanding of organic chemistry, three levels of representations have been discussed: macroscopic, microscopic, and symbolic levels (Gabel, 1998; Johnstone, 1993). At the macroscopic level, chemical changes are observable, for example, burning candles. At the microscopic level chemical phenomena are explained by the arrangement and motion of molecules, atoms, or subatomic particles. Chemistry at the symbolic level is represented by symbols, numbers, formulas, equations, and structures.

Empirical studies (Grifths, 1992) have shown that understanding microscopic and symbolic representations are difficult for students because these representations are invisible and abstract while students' thinking relies heavily on sensory information. In addition, without substantial conceptual knowledge and visual-spatial ability, students are unable to translate one given representation into another (Keig,1993).

To help students understand chemistry at the three levels, researchers have suggested a variety of instructional approaches, such as adapting teaching strategies based on the conceptual change model (Krajcik, 1991), integrating laboratory activities into classroom instruction (Johnstone, 1990), using concrete models (Copolo, 1995), and using technologies as learning tools (Barnea, 1996). Among these approaches, using concrete models as learning tools seems promising. For example, viewing molecular models could help students learn to use microscopic and symbolic representations to describe and explain a chemical process. In addition, manipulating physical models promotes long-term understanding of molecules and atoms (Copolo, 1995).

Like many countries in the world, Ghana places strong emphasis on science education in its educational system. This is in response to the rapid advancement in science and technology which is believed will help the country to surge forward in keeping pace with the process of modernization like the rest of the world. Learning science is therefore, becoming more essential not only for the well being of the individual, but also, for the society as a whole.

However, there have been concerns over low enrolments of senior high school students in the science program in Ghana. Statistics from the Ghana Education Service (GES) as cited in (Anamuah-Mensah, 2007) indicated that, only about 20% of students in senior high schools participate in science stream class. This report expressed concern about the country's growing inability to fulfill national aspirations of producing sufficient science and technology-based manpower. Aside low enrolments of SHS students in the general science program, a much greater concern has been the low pass rate in the WASSCE chemistry Paper. Many students have difficulties in learning symbolic and molecular representations of chemistry.

Many organic compounds were discovered within the nineteenth century. In those days, the names of these compounds were based on their respective sources. For example, a carbon compound from vinegar was named as acetic acid, which takes its name from the Latin word acetum for vinegar; Ethanol was originally named grain alcohol because it was obtained from fermented grains. Formic acid was obtained from ants (in Latin: formicae) and hence the name above.

These old names (that is acetic acid, grain alcohol and formic acid) are currently referred to as 'common' or 'trivial names' (Solomons, 2008). Acoording to (Gillette, 2004) some of the organic compounds took the names of the scientist who discovered them as their trivial names. Typical examples are acetone (C_3H_6O), benezene (C_6H_6) and acetylene (C_2H_2). According to Gillette (2004), some of the organic compounds were having more than one trivial name and this brought confusion among chemists and biochemists all over the world. At the International Union of Pure and Applied Chemistry (IUPAC) convention, held in

1892, scientist deduced a formal system for naming organic compounds hence, IUPAC nomenclature (Solomons, 2008).

Chemists and biochemists from most part of the world today still use the trivial names. According to Fessenden and Fessenden (1990), “The principal principle that guides the IUPAC system of naming is using the structure of the organic compound to derive its name. This makes the names unique for each organic compound and eliminates ambiguity when scientists all over the world are communicating about a particular molecule.

1.3 Statement of the Problem

Some of the general aims in the new chemistry syllabus are: to use appropriate numeric, symbolic, nomenclature and graphic modes of representation and appropriate units of measurement and also develop the ability to communicate ideas, plans, procedures, results, and conclusions of investigations orally, in writing, and/or in electronic presentations, using appropriate language and a variety of formats e.g. data, tables, laboratory reports, presentations, debates and models.

Over the years, the WAEC Chemistry Chief Examiner’s Report lamented on the inability of chemistry students to meet the general aims of the chemistry syllabus especially in organic chemistry. According to the report, most of the students even avoid organic chemistry questions and the few that tackle organic chemistry questions also do not get the naming correct except on rare cases. Naming of organic compounds when the formula is given and writing of the formula from a named compound are key to the mastery of the naming organic compounds. He attributed this to the fact that most teachers do not teach those organic chemistry topics since they are at the latter part of the syllabus and even when they do, it is done very close to the final examination.

Baah's (2009) study conducted in Ghana has revealed that chemistry students from grade A senior high schools performed significantly better than chemistry students from grade C senior high schools in the naming of organic compounds using the IUPAC nomenclature.This shows that some students have problems with the IUPAC system of nomenclature.

The WAEC Chemistry Chief Examiner's report in Ghana has over the years lamented on the weakness of most students in IUPAC nomenclature of organic compounds (WAEC, 2005; 2006; 2007; 2010, 2011, 2012, 2013 and 2014).

In 2013, the Chief Examiner's report showed that many candidates attempted questions on the naming of organic compounds but could not give the IUPAC names of the compounds correctly. In 2014, the report showed that candidates showed weakness as in IUPAC naming of simple organic compounds. For example, most candidates could not name C_6H_5Cl as chlorobenzene. For example, in 2005, candidates could not write the correct IUPAC names of $HCOOCH_3$, $CH_3CHOHCH_2OH$ and

C_6H_5COOH as methyl methanoate, propan-1, 2-diol and phenylmethanoic acid respectively. This problematic situation exists in the researcher's school. Since organic Chemistry is an important aspect of the SHS chemistry programme, it is necessary for workable solutions to be found for the challenges students face in naming organic compounds using the IUPAC system of nomenclature. For this reason this study was design to explore the effect of molecular models on selected SHS student's ability to name organic compounds using the IUPAC system of nomenclature.

1.4 Purpose of the Study

The purpose of this research was to determine whether or not, there were significant differences between the performance of students taught using traditional method of teaching and those taught using molecular models in naming of organic compounds.

Additionally, the purpose was to identify factors that affected students' participation and performance in the naming of organic compounds.

1.5 Objectives of the study

The objectives of the studies were:

1. To determine the difficulties elective chemistry students face when naming organic compounds using the traditional method.
2. To determine differences in the performance of students taught naming of organic compound using molecular models and that of their counterpart taught using the traditional method
3. To determine whether the male students perform significantly better than their female counterparts after being taught naming of organic compounds using molecular models.

1.6 Research Questions

The following research questions guided the investigations:

1. What difficulties do elective chemistry students face when naming organic compounds using the traditional method?

2. What differences exist in the performance of students taught naming of organic compounds using molecular models and that of their counterpart taught using the traditional method?

3. Is the performance of the male students significantly different from that of the female students after being taught naming of organic compounds using molecular models.

1.7 Research Hypotheses

The following were the research or alternative hypotheses of the study:

H_A *1*: There is a significant difference between the performance of elective chemistry students taught with the traditional method and students taught using molecular models.

H_A *2:* There is a significant difference in the performance of male students taught using molecular models and that of their female colleagues.

1.8 Null Hypotheses

The following null hypotheses were formulated for testing during the study:

Ho 1: There is no significant difference between the performance of elective chemistry students taught with the traditional method and students taught using molecular models.

Ho 2: There is no significant difference in the performance of male students taught using molecular models and that of their female colleagues.

1.9 Significance of the Study

The outcome of this study such as 'what difficulties elective chemistry students have in naming and writing the formulae of organic compound by the traditional method of teaching' could help chemistry teachers, head of the science department and anybody who in one way or the other contribute to education in Ghana incorporate new methods of teaching so as to overcome such challenges. The study could further provide chemistry educators with quantitative data as to how far students appreciate and understand the IUPAC system of naming.

1.10 Delimitations of the Study

There were 98 science students in form two at Zion College .These total students were divided into two classes A and B. Science A contained 49 students and science B had 47 students of which form two students offering elective science in Zion College for the 2014/2015 academic year. The population of interest is limited to Zion College Chemistry Students from form two. This is because this class had one year experience and will be in a better position to understand organic chemistry.

The study also limits itself to the use of pretest and posttest to collect quantitative data. The research is also focus on the naming of alkanes, alkenes and alkynes among other organic compounds.

1.11 Limitations of the Study

The research focused on two Science classes of Zion Senior High School. However, the usual school routines and activities interrupted the researcher's work. In addition, a weeklong celebration of Hogbetsotso Festival in the Keta Municipality further disturbed proper interaction with Form two students and this has delayed the conduction of the posttest.

1.12 Organization of the Report

This dissertation has been organized into five chapters. Chapter one discussed background to the study, statement of the problem and purpose of the study. Chapter Two is the review of available literature on the factors that inhibit true science concept formation.

Chapter Three entails the research methodology while Chapter Four deals with the analysis and interpretation of the main findings of field work. Chapter Five provides the summary, conclusions and recommendations of the study.

CHAPTER TWO

LITERATURE REVIEW

2.1 Overview

The purpose of this chapter is to review the literatures related to the study. Introduction to IUPAC nomenclature of organic compounds and Academic Performance being influenced by Genetic Factors and Attitude of Students have being reviewed. The Inadequate Time Allocation for Elective chemistry Practical and Chemistry Students' Performance on IUPAC Nomenclature of Chemical Compound were not exceptions of this literature review. The effect of teacher's beliefs on the academic performance of students, difficulties students face in understanding organic Chemistry as result of English language barrier molecular models were also reviewed.

2.2 Introduction to IUPAC Nomenclature of Organic Compounds

The concept IUPAC nomenclature, which is a formal system of naming organic compounds, was introduced in 1892 by the International Union of Pure and Applied Chemistry (IUPAC) (Fessenden & Fessenden, 1990; Gillette 2004; Heger, 2003; Solomons & Fryhle, 2008). According to Woodcock (1996), there were other systems of naming that came before the emergence of IUPAC system and as such IUPAC names may not be the most commonly used one. Klinger, Kolarik, Fluck, Hofmann-Apitus, and Friedrich, (2008) noted: "trivial names can be searched for with a dictionary-based approach and directly mapped to the corresponding structure at the same time"(p. I268). But IUPAC and the IUPAC related names are identified with respect to the structure of the organic compound (Kolarik et al. as cited in Klinger et al., 2008).

In using the IUPAC nomenclature system to name and write structural formulae of organic compounds, the functional group (which is define as an atom or group of atoms responsible for the chemical behavior of organic compounds) of a compound is taking into consideration (Gillette, 2004; Woodcock, 1996). For example, all alkene, alkynes and alkanol contain $R_2=C=C=R_2$, $R–C \equiv C–R$ and (─OH) group respectively bonded to carbon atom where 'R' can be Hydrogen or alkyl group. According to Skonieczy (2006), preference should always be given to a functional group that has the highest precedence when the organic molecule in question contains more than one functional group. The principal functional group is usually named as the suffix in **table 2** and the others as the prefixes as it appears in **table 1.**

Students' ability to interpret the IUPAC name of an organic compound into its structural formula is the most important compared to the ability of Chemistry students to give the IUPAC name of any given structural formula. In any chemistry examination, if students find it difficult to write a structural formula of any named compound, then they will as well find it difficult to name it since most of the functional groups are hidden in the condense formula as well as the substituents. Therefore if this happens, the performance of such students is affected on such questions (Clark, 2000).

Woodcock (1996) indicated that, though almost every organic compound contains carbon and hydrogen atoms but the IUPAC names of the organic compounds are determine partly by the number of carbon atoms in the longest continuous carbon chain, and other element and group of elements such as functional groups and substituents (Woodcock, 1996). The name is actually silent on the name of hydrogen.

In naming organic compounds, there are three parts that must be considered. These are the root (parent) part; which shows the number of carbon atoms in the longest continuous carbon chain, the suffix which shows the family to which the organic compound belongs or the functional group it contains. The third part is prefix; which is dependent upon the number, position of both organic and inorganic substituents that replaced any hydrogen atom or atoms in the parent compound (Gillette, 2004; Woodcock, 1996).

Gillette (2004) stressed that if any chemistry student is able to apply and interpret these three parts of organic compounds, then he or she will be able to "write the IUPAC names of organic compounds base on their Lewis structures; and draw the Lewis structures for organic compounds based on their IUPAC names. The same will be true for condensed formulae and line-angle drawings".

Gillette (2004) also stated that there are three ways of representing the IUPAC names of organic compounds with structural formulae. The first is the Lewis structure (referred to as expanded structural formula). The Lewis structure shows all the carbon and hydrogen atoms together with any other atom or group of atoms and the covalent bonds connecting them. The second structure is the condensed structural formula, which shows any carbon atoms in the straight chain together with any other atoms or group of atoms connecting to the chain without the covalent bonds or any unshared electron pairs. In the condensed structural formula, the covalent bond is shown only and if only there is the need to clarify a specific portion of the structure for example functional groups (Gillette, 2004). In the line-angle drawing, chemical bonds are shown without the carbon and hydrogen atoms, it uses lines to show chemical bonds. This is the third structural formula representation (Gillette, 2004).

Gillette further mentioned that, irrespective of the method of structural formula used for any particular compound, the presence of any other atom or group of atoms or any multiple bond/s in any particular molecule must be shown. For example, $CH_3CH{=}CHCH_3$. Gillette

(2004) said "to draw the structure of an IUPAC-named compound, we work backwards through the compound name, from the parent name to the prefix" (p. 7). Clark (2000) explained that an IUPAC name of an organic compound is simply a code and that each part of the IUPAC name reveals some useful information about the compound. For example, 2-methylbutan-1-ol could be understood in the following ways:

1. The but- shows the number of carbon atoms in the longest continuous carbon chain (and in this instance, there are four atoms of carbon) (Clark, 2000).

2. The –ane comes immediately after the 'but' shows there is no carbon to carbon multiple bond (Clark, 2000).

3. The 2-methyl shows there is a methyl substituent group which is attached to the second carbon.

4. The -1-ol shows that, there is alkanol functional group attached to the terminal end of the compound.

Clark (2000), was of the view that one has to learn the codes for number of carbon atoms in a continuous carbon chain in order to master naming organic compounds. Table 1 shows the parent name for a particular carbon length in organic compounds.

Table 1: Parent name for the first twelve continuous Carbon Atoms of organic compounds

Parent name	Number of Carbons
Meth	1
Eth	2
Prop	3
But	4
Pent	5
Hex	6
Hept	7
Oct	8
Non	9
Dec	10
Undec	11
Dodec	12

Clark (2000) indicated that if an organic compound contains a carbon-carbon single or multiple bonds, the three letters that come immediately after the parent name (suffix) for the chain length will give an indication. The table 2 shows the suffix for carbon-carbon single and multiple bonds.

Table 2: The suffix of Carbon-Carbon Bonds

Suffix	Interpretation
Ane	the molecule contains only carbon-carbon single bonds
Ene	the molecule contains carbon-carbon double bond
Yne	the molecule contains a carbon-carbon triple bond

In naming a typical alkene, for example $CH_2CHCH_2CH(CH_3)CH_2CH_3$ is name as 4-methyl-1-hexene. To be able to name this compound, the longest continuous carbon chain was determined to be 6 and hence the parent name hex, from the structural formula, the functional group was indicated to be alkene functional group and located at position one on the chain. There is only one organic substituent which is a methyl group and it is also located on the forth carbon on the chain. All these information were put together in naming the compound above.

2.3 Academic Performance being influenced by Genetic Factors and Attitude of Students.

Students' academic performance can be influence by genetic factors that is whether the student inherits higher intelligence or a lower one. Learners who have inherited higher intelligence have higher intellectual efficiency (Vernon, 1969). They are able to learn quickly and progress to a higher stages of the educational ladder. With such students since transfer of learning depends on perception of relationships between situations, they are able to connect the relationship between what they learn easily. Students of such nature can see the connections between two or more different situations and common elements and pervasive principles without the teacher's intervention.

Besides genetic factors, academic performance is greatly influenced by student's attitudes to particular subjects and to their teachers, among other things. Students actively learn by doing, seeing, hearing, tasting or touching or testing, learning is something that students must do for themselves and it is hastened when they are active and willing to participate in the process. Student's activeness and willingness to participate in learning are affected by their attitude towards it. Parents and teacher can help students to develop a positive attitude by providing enabling environment in school so that students can learn to the best of their ability to ensure higher academic performance (Balogun & Okan, 1981).

Furthermore, students need to take responsibility for their learning if they want to perform well in school. According to Nielson (1985), poor students tend to blame their poor performance on sources beyond their control, such as unfair test questions, a prejudiced teacher, bad luck, fate and other factors. Good students on the other hand, take responsibility for their learning.

In addition, Nielson (1985), observed that the grades of good students depend on how prepared and willing they are to apply themselves to study in schools. He further observes that by simply making an increase in the time students spend on homework can positively affect their grades in high school. All these observations points to the fact that attitude of students have profound impact on their school performance. Students who have been most successful in school usually have a more positive attitude towards school than those who have not been successful (Le Francois, 1991).

Annoh (1997) also asserted that transfer of learning, which also influences high academic performance depends to a large extent, on the learners desire to learn effectively. The more a student learns one thing, the greater the possibility that he will perceive connections and relationships in other situations.

2.4 The inadequate time allocation for elective chemistry Practicals

The West African Examination Council (WAEC) (2006) Chief Examiner's in Chemistry stressed that the syllabus was not completed enough before writing the final examination. This is because the time period for teaching all the topics in the theory and the practical is not enough. The normal curriculum is now embedded with so many extra-curriculum activities there by reducing the contact hours for teaching.

Those who think that, time is a valuable resource and therefore have their activities regulated by the clock share this ideology. Time is a non renewable resource and once it is lost, it cannot be gained back by any other means.

2.5 Chemistry Students' Performance in IUPAC Nomenclature of Chemical Compound.

Considering the research work done by Hofstein, Bybee, and Legro (1992), it has revealed that the performance of science students depends on several factors of which the school environment, teaching and learning materials and equipment are not exceptions. This gives an indication that the type of school attended by a student has as an influence on his or her performance in IUPAC nomenclature of organic compounds.

Baah's (2009) study conducted in Ghana found the following: The performance of students from Grade A schools and Grade B schools on naming of compounds by IUPAC nomenclature differed significantly with students from Grade A schools doing better. This is because the mean score for students from Grade A schools (M = 3.80, SD = 1.76) was significantly higher than the mean score of students from Grade B schools (M = 2.085, SD

= 1.710, t(332) = 8.734, p = 0.001) with an effect size of 1.0 (p. 122). Baah (2009) further found that chemistry students from Grade B schools performed significantly less on writing chemical formulae of compounds and on writing chemical equations as compared to their colleagues from Grade A schools. Under the writing of chemical formulae of compounds, Baah reported that the chemistry students from the Grade A schools recorded significantly higher mean score (M = 2.200, SD = 1.669) as compared to the mean score of chemistry students from Grade B schools (M = 0.940, SD = 1.184, t(332) = 1.454, p = 0.001) with 0.8 as the effect size. Under the writing of the chemical equations there was a significant difference between chemistry students from Grade B schools and Grade A schools because the mean score (M = 8.493, SD = 3.357) of chemistry students from the Grade A schools was significantly higher than the mean score (M = 6.364, SD = 3.002, t(332) = 5.872, p = 0.001) with effect size of 0.7 of chemistry students from Grade B schools (Baah, 2009).

Wu, Krajcik, and Soloway (2001) indicated that many students studying chemistry have difficulty learning symbolic and molecular representations. They have conducted a study with 71 eleventh grade students of small public high school in a midsize university town in the Midwest to investigate how chemistry students develop and understand chemical representations using a computer-based visualizingy tool for 6 weeks. One of the chemical concepts studied within the 6 weeks period by Wu et al. (2001) was IUPAC nomenclature of organic compounds such as hydrocarbons. According to Wu (2001), students were able to apply modern rules of IUPAC nomenclature to draw structures of some given organic compounds. For instance, the students were made to name and draw the structure of a six-carbon atom compound with a side group.

The understanding of the high school chemistry students was said to have improved considerably resulting in high performance on IUPAC nomenclature of organic compounds.

This is as a result of the fact that, there was statistical significant difference between the means of pretest (N = 71, M = 31.1) and posttest (N = 71, M = 59.5) results after they had been subjected to a paired two-sample t-test analysis (SD 2.5, t(70) = 13.9 p 0.001) with an effect size of 2.68 (Wu et al., 2001).

2.6 The effect of teacher's beliefs on the academic performance of students.

Developmental and educational theorists have discussed the value of child development knowledge base for the teachers throughout the past century. This unfortunately centered on the behaviorist tradition (Brown, 1994) or on extreme biological views such as entity ideas that intelligence is fixed or maturatonist view that, children develop on their own. In recent time's psychologist drop such beliefs and practices, and rather endorsed educational practices based on knowledge about how children develop and learn (Brown, 1994).

Different groups of psychologist called constructivist, social constructivist and ecological theories have shifted the attention to child-centered practice or learner centered approach. Even though some people believed that the differences between these theories are not reconcilable, others see them to be complementary (Cobb, 1994). One important trend in these theories is that effective teaching must be based on understanding of the child and the vision of the children as active agents in their own education.

John Dewey who provided the foundation for constructivism believed that teachers must balance an understanding of the habits, traits and dispositions of individual children with understanding of means for arousing children's curiosity (Archambault, 1964).

Dewey also believed that, fostering mental growth among children requires teachers who can initiate, recognize, maintain and assess children's inner engagement in the subject matter. The teacher is also concerned with how the child's past and present experiences can be related to the subject matter so that they may properly direct children's mental growth.

A social constructivist (Vygotsky, 1978), also share the similar view with Dewey.

For him, child development and education were inextricably bound together. He used the zone of proximal development to describe a process whereby the teacher who understands children's development can recognize the "buds" of conceptual or skill development as a prelude to guiding the child from a nascent to a more mature form of understanding or skill.

Among other Psychologists, Jean Piaget also believed that basic ideas are relevant to the argument that teachers need to understand child development and are especially important, given the current drive for schools to foster higher order reasoning and create autonomous learners who are able to function successfully in the rapidly changing information age. Piaget mentioned the following to be reasons why a teacher must be able to understand his or her students.

a). Children's' and adults' reasoning differs qualitatively. b). Knowledge is constructed by engaging actively with the physical and social world. c) Abstract thinking is built on concrete experience and d) Conceptual change occurs through assimilation and accommodation. So as a result of these points, Piaget believed that teachers need to design environments and interact with children to encourage invention, creative, critical thinkers. All these can only be achieved if only the teacher understand the child and his or her basic needs. He therefore put it that the task of the teacher is to figure out what the learner already knows and how he reasons in order to ask the right question at the right time so that the learner can build his/her own knowledge.

Bronfenbrenner (1979) mention the importance of understanding children's behavior and establishing productive programs and policies to promote the development of children and youth. He also pointed out that teachers make many decisions such as 'curriculum and instructional decisions about materials and methods used in the classroom' that can be informed by understanding of the context in which children live. Whatever decision that is taken by the teacher must intern be influenced by understanding how the knowledge, practice and language socialization patterns within children's families and communities contribute children's ability to function in the classroom.

Another school of thought called developmental psychologist during the later part of the 20^{th} century also emphasized that ideas about how children learn have enormous implications for teacher education. Studies of problem-solving suggest that teachers need to understand how children approach and solve specific types of problems within content areas and how the development of domain-specific reasoning is linked to "everyday" reasoning (Fish, 1980).

In all these theories, there is one thing that is common, that is "a teacher must know in and out of his/her student".

2.7 Difficulties students face in understanding organic Chemistry as result of English language barrier.

Even though, chemistry is an abstract course and teachers are looking for ways to make it real and practicable for the learners, there are many other obstacles for most learners which inhibit true concept formation. Among these inhibitors is a second language learner. Concept attainment and language development are inextricably linked (Henderson,1998). Thought requires language and language also requires thought (Wellinton, 2001). Explained from Vygotskyian point of view, when a learner uses words, he or she is helped to develop concepts. Language thus acts as a psychological tool that help a learner to form thought as well as a proper mental functioning.

Children try to make sense from taught by trying to fit it in their own experiences. Thus the child socio-cultural background and linguistic tools available to him or her plays a significant role in concept development. Wellington and Osborne stress in Science education that research finding s indicated that language in all its forms matters to science education. It is not the language itself but what rather the educators do with the language (Wellinton, 2001).

Every language contained several words of which each of them is a 'concept'. But unfortunately scientific concepts can fully be express when words are joined in a sentence (Gordon, 1972).

2.8 Molecular Model

A molecular model is a physical model that represents molecules and their processes. Molecular models most at times refer to systems containing more than one atom and where nuclear structure is neglected. The electronic structure is often also omitted or represented in a highly simplified way.

August Wilhelm von Hofmann is credited with the first physical molecular model around 1860. Physical models of atomistic systems have played an important role in understanding chemistry and generating and testing hypotheses. There are several motivations for creating physical molecular models.

Molecular Models serve as

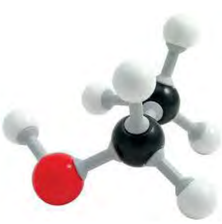
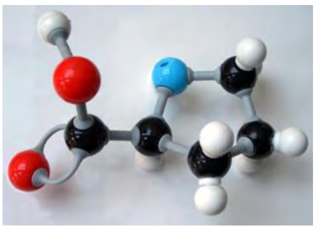
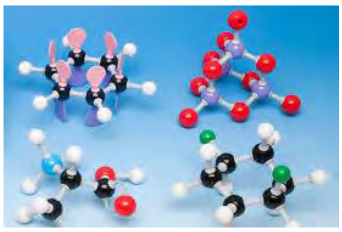
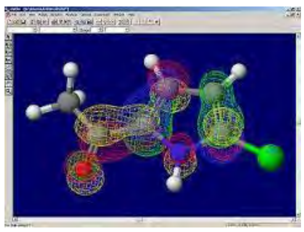
- pedagogical tools for students or those unfamiliar with atomistic structures.
- objects to generate or test theories.
- analogue computers (e.g. For measuring distances and angles in flexible systems).
- aesthetically pleasing object on the boundary of art and science.

The construction of physical models is often a creative act and many are bespoke. Most have been carefully created in the workshops of science departments.

Though molecular graphics has replaced some functions of physical molecular models, the physical kits continue to be very popular and are solid in large numbers. There unique strengths of the molecular models include:

- Cheapness and portability.
- Immediate tactile and visual messages.
- Easy interactivity for many processes (e.g. Conformational analysis and pseudo rotation).

In the 1600s, Johannes Kepler speculated on the symmetry of snowflakes and also on the close packing of spherical objects such as fruit. This problem remained unsolved until very recently. The symmetrical arrangement of closely packed spheres in form theories of molecular structure in the late 1800s and many theories of crystallograghy and solid state inorganic compounds used collection of equal and unequal spheres to simulate packing and predict structure (Wooster,1945).These are some examples of molecular models

The black colors represent carbon atom in the first three examples. Other colors could be used to represent anything depending upon what the instructor want.

2.9 Gender and Academic Achievement.

Academic performance of boys and girls has never been the same over the years. Acording to Stevenson (1987), most of the studies have shown that, on the average, girls do better in school than boys. Girls get higher grades and complete higher school at a higher rate compared to boys. There are certain areas like spelling, writing, aptitude test and general knowledge; girls outperform the boys (Halpern, 2000). Most of the studies have shown that, on the average, girls do better in school than boys.

At grade four, the performance of boys and girls remain virtually the same in Mathematics, but turns in favor of boys beyond grade four. However the performance of boys in science begins to be better than the girls from grade four up words. This notwithstanding, the girls continue to exhibit higher verbal ability throughout high school.

These gender differences in mathematics and science achievement have implications for girls future careers and have been a source of concern for educators all over the world.

According to (Pajares, 2001), these differences can be traced to gender differences in cognitive ability of middle school students. Girls are endowed with verbal skills tasks such as verbal reasoning, verbal fluency, comprehension and understanding logical reasoning. On the other hand, boys perform better than the girls in spatial skills tasks such as mental rotaion, spatial perception and spatial visualization (Benbow, 1988).

The explanation to boys performing in Mathematics better than the girls is attributed to the fact that boys have greater confidence in their Mathematics skills, which is a strong predictor of Mathematics performance (Eccles, 1986). Their inability to understand these basic Mathematics and science account for their low numbers in Mathematics and science related courses in the colleges like engineering and computer sciences for example.

CHAPTER THREE

METHODOLOGY

3.1 Overview

This chapter discusses the various steps that are pursued and the procedures that have been carried out to conduct this study successfully. Specific parts that have been covered are research design, population, sample and sampling procedure, research instrument, validity and reliability, data collection procedure and data analysis.

3.2 Research Design

The choice of research design must be appropriate for the research questions under investigation. In the quest for the appropriate design, the researcher came across several research designs such as descriptive survey, case study, developmental research, experimental and quasi-experimental.

For this research, the researcher selected the quasi experimental research design as the most appropriate. Experimental research method is a systematic and scientific approach in which the researcher manipulates one or more variables and controls, measures any change in the other variables. Experimental research helps us to confirm why there is a difference in two or more methods of doing things and so doing improve our lives.

3.3 Population

There were 10 Senior High Schools in Keta Municipality, consisting of 9 public schools and 1 private school for the 2014/2015 academic year. Out of these 10 schools in the Keta Municipality, only three offer elective science. Zion Senior High was the only school selected from these three for the study, because that was where the researcher at the time was teaching. The target population for the study was all form two Students in Zion Senior High school who were offering elective Chemistry for the 2014/2015 academic year. From this population the researcher made generalization for the science students in Zion Senior High School. This was because the form two Chemistry students have studied Chemistry for nearly two years and they were in the better position to contribute to the study.

3.4 Sample and Sampling Procedure

The target population was chemistry students in Zion Senior High School form two which comprises 98 students. A coin was tossed between the two class captains from Science A and B. The class captain from each of the science classes were asked to pick a piece of paper labeled control group and experimental group. Science A became the control group whiles Science B became the experimental group as a result of the toss. Reducing sampling errors were vital to the researcher that was why he tossed to avoid being biases.

Both classes took pretest on the same set of questions about naming and writing of the structure of named organic compounds. The pretest helped to prepare the ground for comparing the two classes and to confirm if there was significant difference between the cognitive level of the two classes.

A posttest was conducted on the same set of topics on naming and writing the structure formula of organic compounds after science A was taught with the traditional method while science B was subjected to the test instrument. Both the pretest and the posttest helped answer the research question 'What difficulties do elective chemistry students face when naming and writing the structure of organic compounds using the traditional method of instruction'?

The posttest helped answer the research question 'To what extent will the use of molecular models improve the performance of the students in the naming and writing the structure of organic compounds?

3.5 Research Instruments

Achievement test was the instrument used for the data collection. The instrument consists of pretest and posttest. The test items for the pretest were 3 questions but each question was categories into 8 sub-questions. The posttest was made up of 5 questions and each question was categorized into 8 sub-questions. The test items were drawn from examination past papers. The test items were validated based on the existing course content on nomenclature and writing of the structure of organic hydrocarbon compounds. The instrument consists of two sections, A and B. Section A which is the pretest, consisted of 24 test items meant to elicit prior performance of students in naming and writing the structure of organic compounds.

Section B which is the posttest about naming and writing the structure formula of organic hydrocarbon compounds and were given to both classes after the traditional method of teaching and the intervention approach. The researcher organized the two lessons and their respective pretest and posttest in such a manner to avoid John Henry Effect. The John Henry effect is the unexpected outcome of an experiment as a result the control group become aware of the instrument and working harder to cancel the effect of the intervention. The test items increased in complexity from the first to the last in order to cater for the thinking levels of the students. The time allowed for the pretest was 40 minutes and that of the posttest was 1 hour. Every correct category question attracted one mark.

3.6 Reliability of the main instrument.

Reliability is the consistency of your measurement, or the degree to which an instrument measures the same way each time it is used under the same condition with the same subjects (Remmers, 1934).

Some of the questions used in this research were selected from the terminal examination past questions of Zion College from 2010 to 2015. The other questions were modified questions from the past questions of the West African Examination Council. This was to ensure that the questions were appropriate, in order to measure the West African academic standards questions in naming of organic hydrocarbon.

A parallel form of reliability was used. Parallel reliability is a measure of reliability obtained by administering different versions of an assessment tool where both versions contain items that probe the same construct, skill, knowledge base to the same group of individuals. The questions of the pretest were not different from that of the posttest only that, the posttest was a bit difficult. But they were all probing the same knowledge.

3.7 Validity of the main instrument.

Validity of the research instrument is the extent to which a test is subjectively viewed as covering the concept it purpose to measure (Patton, 2007).

Face validity and content validity of the instrument were addressed. To be able to draw meaningful and good conclusion based on the participants score from the pretest and posttest, both test instruments were presented to my project supervisor who is a senior chemistry lecturer in order for him to correct the errors that were associated with items on the pretest and posttest questions.

The content validation is determined by the appropriateness of the content material, clarity of the test items and instruction. The content validity of the instrument was assessed by the researcher's supervisor to make sure that the test questions were based on the research questions. Its validity was further enhanced through pre-testing and post-testing.

3.8 Data collection procedure

The sampled students were administered with pretest before the treatment strategy to the experimental group. The pretest lasted 40 minutes and was supervised by the researcher and another chemistry teacher. Students scores obtained from the pretest were recorded and analyzed.

Both the control class and the experimental class were taught for the second time where the control class was taught using the traditional method of instruction and the experimental class was taught using molecular models.

3.9 Sample treatment

- Control Class: All the rules regarding naming of organic compounds were stated to the class as follows.

1. Count the longest continuous carbon chain and name it as the parent structure.

2. Any group of atoms which do not form part of the parent structure is called a substituent or side group. The names of all side groups come before the name of the parent structure.

3. There are two types of substituents: organic and inorganic substituents. All the inorganic substituents are name first in alphabetical order followed by organic substituents also in alphabetical order if the two types of substituents occur on the same molecule.

4. The position of substituents on the parent structure is indicated with the least location number.

5. If a particular substituent occurs twice or more times, the number of times it occurs is indicated by the Greek prefixes as di, tri, tetra etc. for 2, 3 and 4 respectively.

6. In naming, numbers are separated from each other by commas (,) and numbers from each other by hyphens (-).

7. The inorganic substituents such as chlorine, bromine, Iodine, amine are named as chloro, bromo, iodo and amino respectively.

8. The organic substituents such as CH_3, CH_3CH_2, $CH_3CH_2CH_2$, $CH_3CH_2CH_2CH_2$ are also named as methyl, ethyl, propyl and butyl respectively.

9. During the naming, all the substituents are named first followed by the parent name.

10. The whole name appears as one name.

After stating all these rules the structures of three condense formula compounds were drawn on the board and by the help of the teacher all the three compounds were named. Students from the control class also repeated it for several other organic compounds.

- Experimental class: All the rules that appeared in the control class were also mentioned in the experimental class except that the structures of the three organic compounds were modeled for the students to see before the teacher assisted the students in naming. Students from the experimental class also repeated the naming for several other organic compounds.

After these teachings, a posttest was conducted, marked and the results were also recorded. Some of the marked scripts are found in appendix I

3.10 Data analysis.

The statistical tools used to analyze the pretest and posttest were the frequency count, percentages and the student's *t*-test. Data obtained from both pretest and posttest were analyzed using *t*-test to determine whether there was a significant between the experimental class and the control class. The null hypothesis was tested at 0.05 level of significant or 95% confidence level. Means were used to establish if there is a significant difference between the performance of boys and girls in the experimental class.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Overview

This chapter presents the results and discussion from the study of the effect of using molecular models on the performance of SHS students in naming of organic compounds by the IUPAC system based on the research questions.

4.2 Background Data on the Research Subject

A total of 86 students took part in both pretest and posttest out of 93. Exactly 42 students came from the control class where 44 came from the experimental class. The control class had 30 boys and the remaining 12 were girls but the experimental class had 30 boys whiles the remaining 14 were girls. The average age of boys and girls in the control class was 21 and 19 respectively and that of the experimental class was 20 and 19 respectively.

At the start, there was a brief introduction of organic compounds to both classes after which a pretest was conducted. During a different lesson, the control class was taught using the chalk board whereas the experimental class was taught using the molecular models. At the end of each lesson, the same posttest assessment questions were conducted for both the control and experimental class.

4.3 Research Question one.

What difficulties do elective chemistry students face when naming organic compounds using the traditional method?

4.4 Difficulties students face in the pretest

It was noticed that, even though some students from both the control and experimental class gave correct answers to the lower level category questions, they fail to provide answers to the higher level category questions. Meanwhile, the lower level category questions must all be correct in order to get a higher level category questions right since the higher ones are continuation of the lower category questions. This accounts for the poor performance during the pretest.

The following were the difficulties the students faced during the pretest

- Inability to locate the longest continuous carbon chain
- Some students counted all the carbon atoms in the molecule including the carbons found in the organic substituent such as methyl and ethyl groups and used it for the longest continuous carbon chain; hence their parent names were wrong.
- Difficulty of locating the functional group.
- The students could also not indicate the position of both the substituents and the functional groups.
- Nearly 90% of them could not combine the many rules in order to name at most one compound out of the three compounds provided.

4.5 Difficulties students faced in drawing the structural formula of the compounds after the intervention.

Generally, most students in both the experimental and control classes could draw the structural formula correctly and hence the longest continuous carbon chain. During the drawing of the structural formula, they have encountered several challenges that reflected in the result. One of the challenges is;

- Some students counted all the carbon atoms in the molecule including the carbons found in the organic substituent such as methyl and ethyl groups and used it for the longest continuous carbon. A typical example is found in compound A. $(CH_3)_2CHCH_2CHBrCH_2CH_3$. The actual name of the compound is **3-bromo-5-methylhexene**. The parent name in this compound was **hex** for 6 continuous carbon chains, but some students mentioned **hept** for 7 continuous carbon chain. This implies that the students have added the methyl group to the parent name that is **hex** and make it the continuous carbon chain. Though, there were some few instances where students from the experimental class also made the same mistake, their number was very few because of the fact that molecular model might have improved their performance.
- Another example is compound C). $(CH_3)_2$ CHCH (CH_3) CH_2 CC $CH_2CH_2CH_3$. In this compound, for example the longest continuous carbon chain is 9, and there were two methyl substituent in the molecule so the name of the compound should be **7, 8-dimethyl-4-nonyne.** But the students added these methyl substituents to the longest continuous carbon chain making it 11 continuous carbon chain instead of 9.
- Others were confused; they drew the structure of the molecule by surrounding carbon with several bonds than four. They have disobeyed the tetrahedral rule for carbon.

4.6 Challenges in giving IUPAC names of compounds

Both control and the experimental classes faced some challenges during the naming of the organic compounds. Some of them are as follow;

- Difficulty of giving the correct location number to the substituent.
- Difficulty of giving the correct position to the functional groups.
- Difficulty of establishing if there is a multiple bond in an organic compound from the condense formula.
- If there is two, three or four substituent, some students failed to indicate it using di, tri and tetra respectively.
- Some failed to separate numbers with comers and number from words with hyphens.
- Difficulty of which substituent should be named first. Some students mixed the organic with the inorganic substituent. Some even named the organic substituent first.

These are some of the practical evidences that the researcher encountered during marking of the scripts of the posttest that showed that they had difficulties as mentioned above during the naming.

In considering A). $(CH_3)_2$ $CHCH_2CHBrCH_2CH_3$. The correct name for compound A above is **4-bromo-2-Methylhexane** but some of the students from both classes named them wrongly as;

A. 3-bromoheptane
B. Bromoethane
C. 2-bromo-1-dimethylpentane
D. 3-bromo-6,6-dimethylheptene
E. 2,6methyl5-cyano6-iodo pentane

The wrong name C was wrong because the position of bromine was wrong, and instead of one methyl group, he/she took part of the parent name to be a substituent making it two methyl groups.

Looking at compound C). $(CH_3)_2CHCH(CH_3)$ CH_2 CC $CH_2CH_2CH_3$, the correct name for compound C. above is **7, 8-dimethyl-4-nonyne** but due to some difficulties, some students named them as

a. 5-methyl,6ethane alkene
b. 4methyl,6-ethlyoctane
c. 4-ethyldecyne
d. 3,4dimethylpetene
e. 7-methyl-4-nonyne

As can be seen from these wrong names, though the names were wrong, only wrong the students who got name (e) used the hyphens correctly.

4.7 Difficulties in locating the longest continuous carbon chain

One of the major problems associated with locating the longest continuous carbon chain was branching. Once the molecule is branched, it becomes a difficult task for the students to trace the longest chain. This has reflected in the result as more students were able to locate the chain in unbranch compounds as compared to the branched molecules.

4.8 Research question two.

What differences exist in the performance of students taught naming of organic compounds using molecular models and that of their counterpart taught using the traditional method?

4.9 Performance of students in the posttest.

In exception of one student from the experimental class, no student scored 3/3. The general performance of both classes were very poor as 37 students scored zero out of 42 in giving the IUPAC names of the compounds whiles 33 out of 44 students scored zero. The only student who scored 3 out of 3 had a record of repeating second year. The result is display in appendix E.

4.10 The average performance of students in all category questions

Figure 1 shows huge disparities in the performances of the two classes. Though there has being a general improvement in the results for both classes in the posttest over the pretest the performance was low as expected. Some students in the control class also excelled in the posttest but not as better compared to the experimental class.

Whereas 27.6% of students in the experimental class named all the five compounds correctly, only 13.06% of those in the control class named all the five compounds. The control class had as high as 30.35% failing; meaning 30.35% percentage could not name any of the five compounds correctly where as 21.6% of the experimental class could also not name any of the five compounds correctly. The sum of the percentages of students from the control class that got at least 3marks for all categories is 35.71% and the remaining 64.29% scored below 3marks. On the other hand, 50.30% of students from the experimental class scored marks from 3 upwards but the remaining which is 49.70% also failed. This implies that 14.59% from the experimental class passed more compared to the members from the control class. This result is display in **figure 1** below.

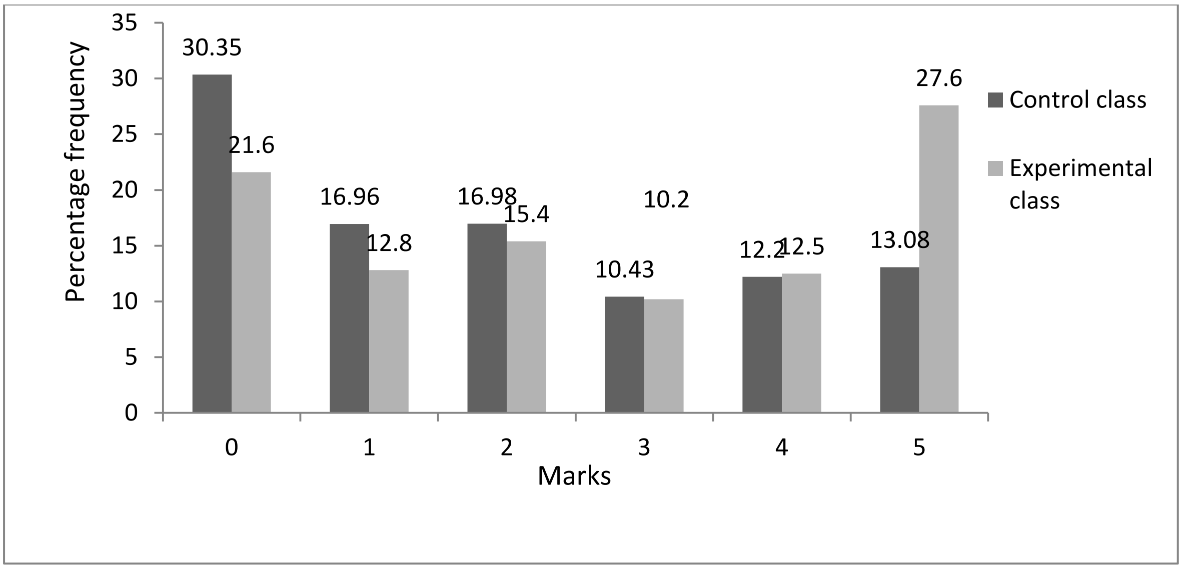


Figure 1. Bar chart of students' performance on average percentages frequency for each mark obtained in all category questions

The visual explanation that the experimental class experience may probably gave them a better understanding than the control class. Fowler (1991) argues that, there is the need to provide the fuel that will ignite the mind, spark the aspirations, and illuminate the total being. The molecular models can often serve as that fuel in the sense that they are the ways through which we are able to see our imagination, thought, and making the students believe that science is real but not virtual, Riley (as cited n.cx vmokvmxc; in Cornett 2003) says that the visual aids teach young people how to learn by giving them the first step that is the desire to learn.

4.11 Performance in drawing the structural formula of compounds

Considering the Table 3 and Figure 2 below, 17 out of 44 students from the experimental class scored 5/5 as against 4 out of 42 students from the control class scored 5/5 in drawing the structural formula of the compounds. On the other hand, 3 students from the experimental class scored 0/5 while 11 students scored 0/5 from the control class. The total number of students from the control class that scored below 3marks is 26 and this represent

61.9% compared to the experimental class where 17 students scored below 3marks representing 38.6% in drawing the structural formula of organic compounds. This difference could be as result of the intervention that is the use of molecular models in teaching

Table 3. Frequency of marks obtained in drawing the structural formula of compounds

Category question	Mark	Mark (1	Mark (2	Mark (3	Mark(4)	Mark (5)
Control class	**11**	**4**	**11**	**2**	**10**	**4**
Experimental cl:	**3**	**6**	**8**	**3**	**7**	**17**

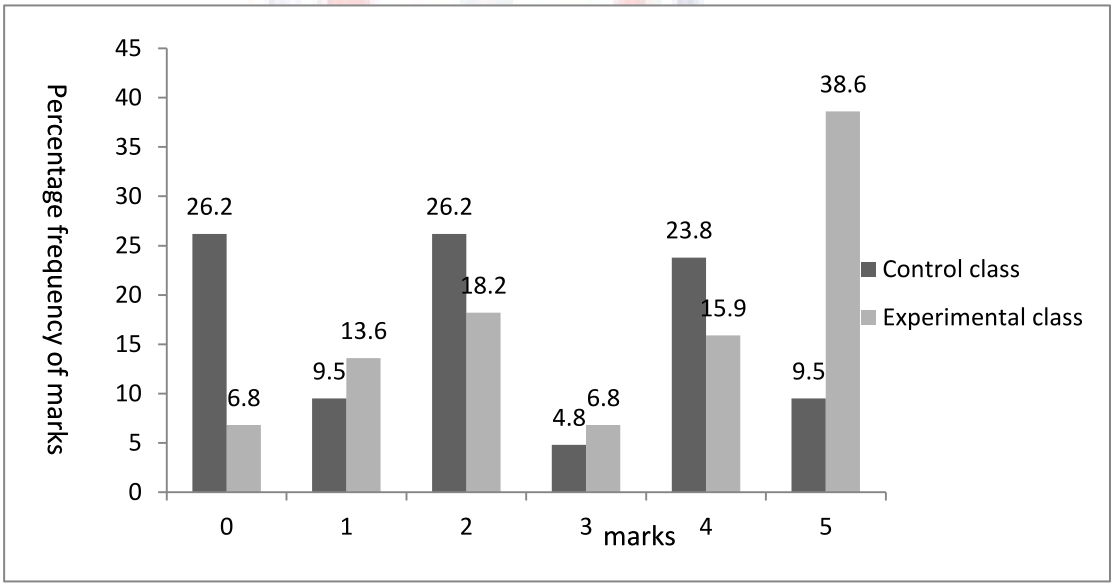


Figure 2. Percentage frequency scores in structural formula against Marks**.**

4.12 Performance in giving IUPAC names of compounds

The ability of students to establish the true structure formula of organic compound is having direct link to the mastery of naming organic compound. This fact is supported by the result from the posttest. As can be seen from Figure 3 below, only 7.1% were able to name all five compounds from the control class, where as 18.2% from the experimental class named all the five compounds. As can be seen from the results of the **Table 3 and 4** of structural formula and IUPAC name of compounds respectively, there is a direct proportionality between getting the structural formula right and naming the compounds using the IUPAC rules.

Table 4 Frequency of marks obtained in IUPAC naming of compounds

Category question	Mark (0	Mark (1	Mark (2	Mark (3	Mark (4	Mark (5
Control class	19	9	8	2	1	3
Experimental clas	20	4	5	2	5	8

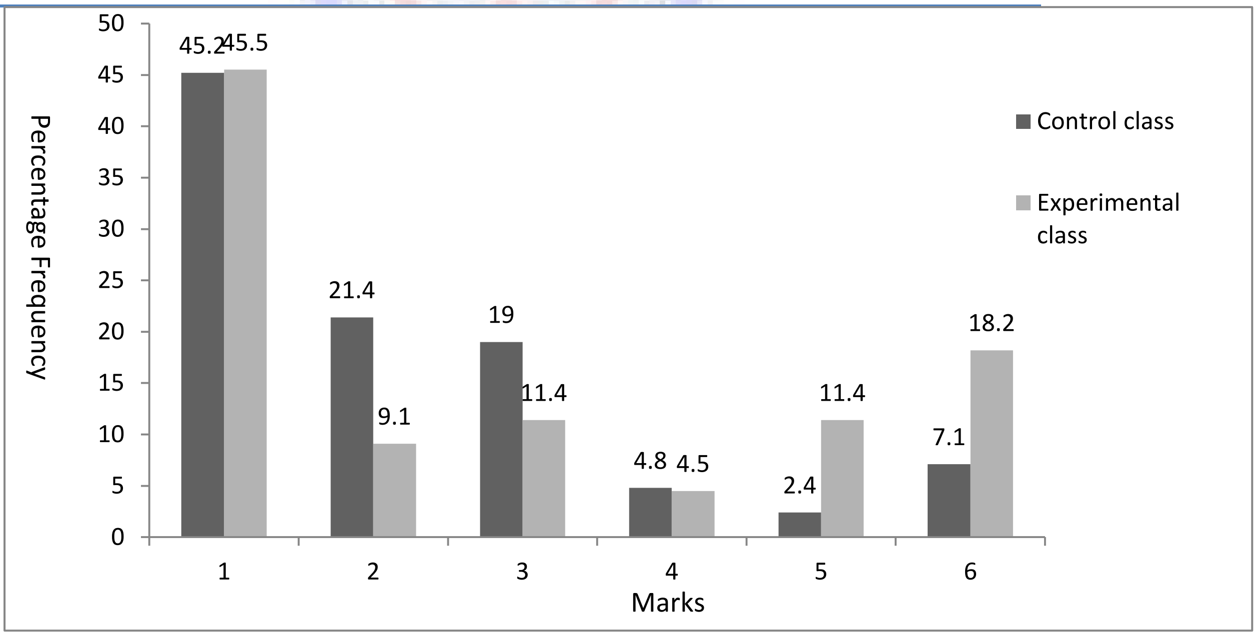


Figure 3. Percentage frequencies of marks obtained in IUPAC naming of compounds

Grifths and Preston (1992) have shown that understanding microscopic and symbolic representations are difficult for students because these representations are invisible and abstract while students thinking rely heavily only on sensory information. As a result of the intervention, the students in the experimental class had the chance to feel, see and handle the modeled molecules which helped their thinking as proposed by Grifths and Preston. Keig (1993) threw more light that without substantial conceptual knowledge and visual-spatial ability, students are unable to translate one given representation into another. Despite the many rules students have to apply, the experimental group performed better due to the practical experience since it is easier to keep information from practical experience than theoretical one.

4.13 Performance in locating the longest continuous carbon chain.

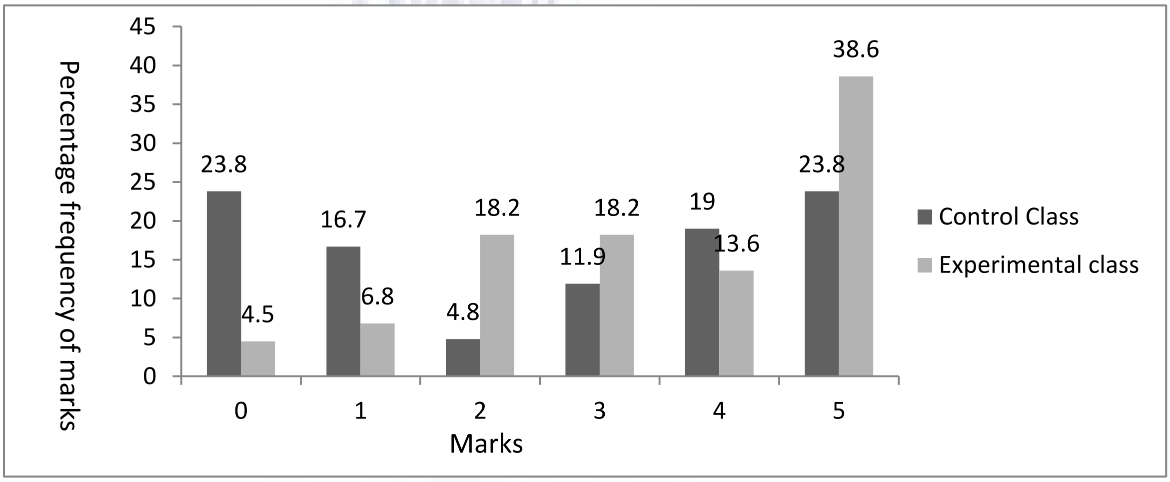
Getting access to the correct longest continuous carbon chain rest solely on getting the structural formula right. That may be the reason why the experimental class still performed better than the control class. From Table 5, only 10 students scored 5/5 from the control class whiles 17 students scored 5/5 from the experimental class which represent 23.8% and 38.6% respectively. Meanwhile, more students failed from the control class compared to the experimental class in terms of identifying the longest continuous carbon chain that is 19 students scored less than 3/5 from the control class while 13 students scored less than 3/5 from the experimental class which represent 45.3% and 29.5% respectively in figure 4.

Table 5 Frequency of marks obtained in longest continuous carbon chain

Marks	Mark (0	Mark (1	Mark (2)	Mark (3)	Mark (4)	Mark (5
Control class	10	7	2	5	8	10
Experimental clas	2	3	8	8	6	17

Figure 4. Percentage frequency of marks obtained in longest continuous carbon chain of compounds.

Identifying functional group was one of the major challenges that faced both classes. From Table 6, only 3 students out of 42 students identify correctly functional group of the five



compounds and this

4.14 Performance in identifying functional groups and their positions in an organic compound.

represent 7.14% in the control class in the posttest assessment. Unlike the control class, the situation for the experimental class was a bit different; 12 students scored 5/5 out of 44 students representing 27.3%. Though there were other intermediate performances where the control class did better for instant, 11 students from the control class scored 2/5 representing 26.2% compared to the experimental class which is 15.9% as shown in figure 5, the experimental class generally performed better.

Though the instrument used was deficient in showing multiple bonds, the students were taught that whenever the hydrogen given in the formula has being used up completely and still all the carbons are not surrounded by four bonds (saturated by hydrogen), then it means there is an indication of multiple bond. In this case, the experimental class was counting the Hydrogen first and beginning to attach them to the carbon atoms. So this will continue until the hydrogens in the formula are finished. For the experimental class there were holes on the central carbon atom which guided the students. Unlike the experimental class, the control class could only draw the compound on the board, they did not even see holes to guide them as to where to place the hydrogen and where not to. So on the part of the control class, some of the students identified the five compounds as alkanes; the others do not indicate anything at all.

Table 6. Frequency of marks obtained in Functional groups

Category question	Mark (0	Mark (1	Mark (2	Mark (3	Mark (4	Mark (5
Control class	11	7	11	3	7	3
Experimental clas	9	8	7	6	2	12

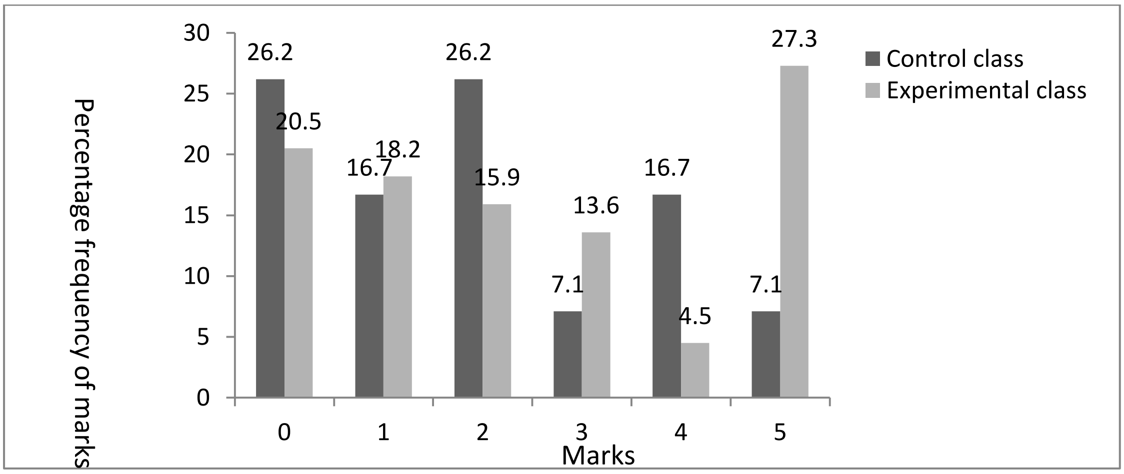


Figure 5 Percentage frequencies of scores in functional groups against Marks

In a total, 11 students from the control class scored 0/5 while 9 scored 0/5 from the experimental class representing 26.19% and 20.45% respectively from Table 6 and figure 5.

4.15 Performance in locating the position of substituents.

Locating the position of substituent is as difficult as that of a locating the position of a functional group. The tasks include getting the actual position on the parent chain, separating the location numbers with a comma, and then the number from names by hyphen. Students must also be able to identify if there are two or more of the same substituent on the same parent chain in so doing indicate them appropriately using 'di, tri tetra' to represent 2, 3 and 4 respectively.

Considering Table 7, only 15 students from the control class were able to score at least 3/5 representing 35.7% whiles 20 students from the experimental class scored at least 3/5 representing 45.5% as found in figure 6. Before students will be able to locate the position of substituents, they must get the structure of the compounds right. This may account for the reason why the experimental class performed better than the control class because they had a three dimensional view of the molecule and probably saw the substituents in different colors. It is easy for the experimental class to identify the substituents if the true structure of the molecules is established.

Table 7. Frequency of marks obtained in locating the position of substituent.

Marks	Mark (0	Mark (1	Mark (2	Mark (3	Mark (4	Mark (5
Control class	19	6	2	7	4	4
Experimental clas	14	8	2	6	5	9

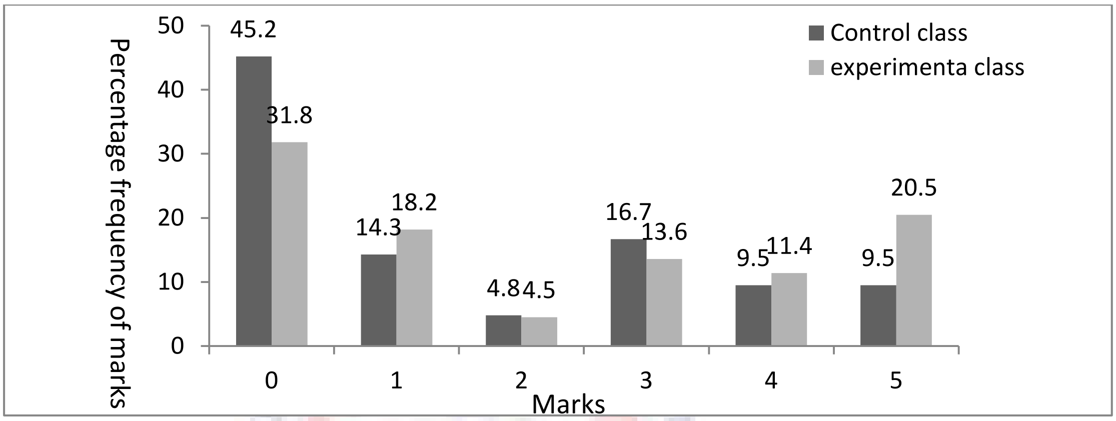


Figure 6. Percentage frequency of scores obtained in locating the position of substituent against marks

4.16 Research Question 3

Is the performance of the boys significantly different from that of the girls after being taught naming of organic compounds using molecular models?

Considering boys and girls in the experimental class**,** a total of 51.2% of the girls scored at least 3/5 whiles only 48.2% of the boys scored at least 3/5. This means that, the girls performed better than the boys.

From literature, the performance of boys and girls remain virtually the same in Mathematics, but turns in favor of boys beyond grade four. However the performance of boys in science begins to be better than the girls from grade four up words. This notwithstanding, the girls continue to exhibit higher verbal ability throughout high school.

The contradiction found in this research could be attributed to the fact that the examples used in teaching the IUPAC nomenclature of organic compounds favored the girls more. It could also be attributed to the enough time and chance the girls had during the practical section since their number was small compared to the boys. This is displayed in the figure 7 below.

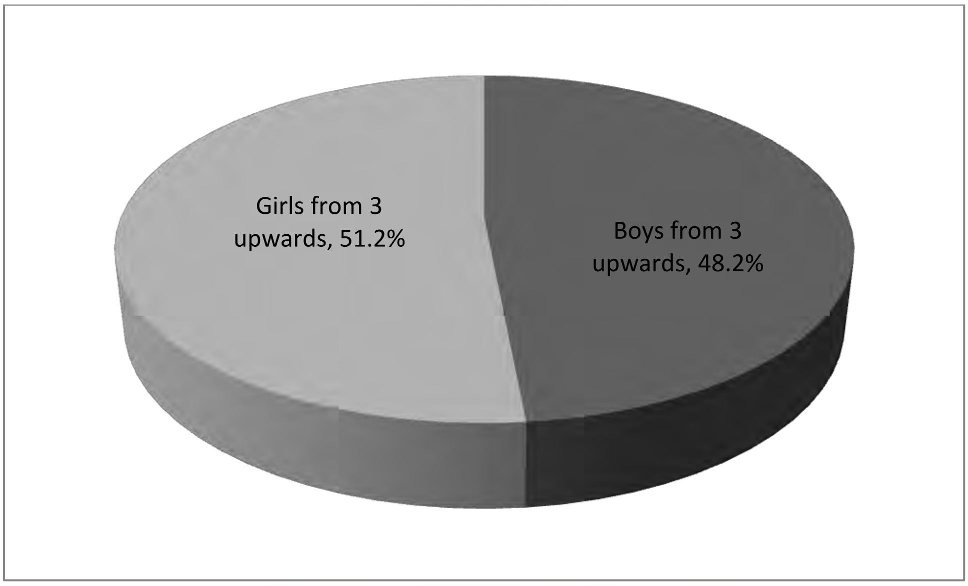


Figure 7. Percentage of boys and girls in the experimental class who scored at least 3/5 in naming the organic compounds.

4.17 Null Hypotheses testing

Ho 1: There is no significant difference between the performance of elective chemistry students taught with the traditional method and students taught using molecular models.

H_A *1*: There is a significant difference between the performance of elective chemistry students taught with the traditional method and students taught using molecular models.

The mean marks of the control and the experimental classes ware 1.19 and 1.59 respectively in naming the organic compounds. The means were calculated from the data in Table 6 above. The calculated P(T<=t) is 0.095 which is greater than the alpha value 0.05 implying that there is no significant difference between the performance of elective chemistry students taught with the traditional method and students taught using molecular models. In the light of this analysis therefore, the researcher failed to reject the first null hypothesis (H_o *1*) formulated for the study.

Ho 2: There is no significant difference in the performance of boys taught using molecular models and that of the girl.

H_A *2:* There is a significant difference in the performance of boys taught using molecular models and that of the girls.

The mean marks of the boys and the girls in the experimental class were 1.86 and 1.71 respectively. The means were calculated from the date in **Appendix G**. The calculated P(T<=t) is 0.034 which is less than the alpha value 0.05 implying that there is a significant difference in the performance of boys taught using molecular models and that of the girls. In the light of this analysis therefore, the researcher reject the second null hypothesis (H_o *2*) formulated for the study.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Overview

In this chapter, the key findings are highlighted and recommendations were given that may enable Chemistry teachers improve on the teaching of naming organic compounds in Senior High Schools.

5.2 Summary of key findings.

The followings were the researcher's observations during the Pretest and the posttest assessments.

1. A total of 27.6% of students in the experimental class named all the five compounds correctly only 13.06% of those in the control class named all the five compounds. The percentage of the control class that failed completely was 30.35% meaning they could not name any of the five compounds correctly where 21.6% of the experimental class could also not name any of the five compounds correctly.
2. Locating the functional groups and their position were some of the major problems the students faced in the naming of organic compounds by the IUPAC principle. Though the atomic model has reduced most of the difficulties, it fails to remove locating the functional group problem since the molecular models do not have provision for multiple bonds.
3. Branching in the main chain also post many problems to the students especially the control group. Most of them could not trace the longest continuous carbon chain because the branches were located in the compounds. They sometimes use branch groups to be substituent which must not be a substituent.

4. The researcher also found out that there is a direct proportionality in the performance of student getting the structural formula right and naming the compounds using the IUPAC rules.
5. There are many rules in naming organic compounds using the IUPAC system of naming and if students do not pay enough attention, a violation of any of the rules will lead to getting the name wrong. This is because the result indicated that most of the students performed in the lower level category questions but as they continue and approaching the naming they finally deviated.

5.3 Conclusion

It is evident from the results of the research work that the use of molecular model has improved the performances of students in the experimental class over the control class. Despite the little improvement, molecular model can be useful as an integral part of teaching organic chemistry in order in improve the performances of students who learn by practice. For instance, some students who were known to perform poorly in class were also able to score good marks in the posttest. In naming the organic compounds the result indicated that there was no significant difference between the performance of the control and the experimental class, so the researcher fails to reject the null hypothesis 1.

On the other hand, the girls performed slightly better than the boys, this statistically is significant at 95% confidence level and so, the researcher rejects the null hypothesis 2 and the alternative hypothesis holds.

5.4 Recommendations

Base upon the findings of the research work. The following recommendations have been made:

- Teachers need to make their lessons lively and practical by improving on teaching and learning materials.

- Understanding chemistry required more time than most other subject so more time need to be created on the time table to help practical periods.
- A research work like this should be undertaken only by external funding in order to buy these expensive molecular models.
- Modern molecular models with a provision for multiple bonds should be used in order for the students to identify the functional groups in compounds.

5.5 Suggestions for further research.

Owing to the conclusions drawn from this study, the researcher recommends the following for further research.

- The same study should be carried out in other schools to provide a means of reference for other researchers.
- Means of enhancing student's interest in organic chemistry must be explored.
- The research work should be extended to cover many other schools for larger sample to be collected than collected in this study.
- The same research work should be carried out but with molecular models that can cater for multiple bond in order for the students to be able to identify the functional groups.

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APPENDIX A

PRETEST ON IUPAC NOMENCLATURE OF ORGANIC COMPOUNDS

Biographic Data

Gender: Male [ ] Female [ ] Age [ ]

Name of School: ……………………………………………………….

This pretest seeks to find out your understanding of IUPAC nomenclature of organic compounds. Please provide the responses in the spaces provided. Your performance will be used for research purposes only and will be highly confidential. You are therefore to respond to the items to the best of your ability. Use 40 minutes to respond to the items after which your paper will be collected. Each answer to a sub question attracts 1mark

Consider the following organic compounds

A). $(CH_3)_3\ CCHCHCH_3$

B). $CH_3C(CH_3)_2CHBrCH(CH_3)CH_3$

C). $(CH_3)_2CHCH(CH_3)CCCH_2CH_3$

1. Indicate below the longest continuous carbon chain and the parent name in each of the above organic compounds labeled A, B and C.

Compound	Longest continuous carbon chain	Parent name
A		
B		
C		

2. Indicate below the name of the substituent and their respective positions in each of the organic compounds labeled A, B and C above.

Compound	Substituent/s	Position of substituent
A		
B		
C		

3. Name the functional groups present and their respective positions in each of the organic molecules labeled A, B and C above in the table below.

Compound	Functional groups	Position of functional groups
A		
B		
C		

4. Draw below the structural formula for the condense formula for each of the hydrocarbon compounds labeled A, B and C above.

Compound	Structural formula
A	
B	
C	

5. Name each of the above compounds labeled A, B and C now

COMPOUI	IUPAC NAME
A	
B	
C	

APPENDIX B

POSTTEST ON IUPAC NOMENCLATURE OF ORGANIC COMPOUNDS

Biographic Data

Gender: Male [ ] Female [ ] Age [ ]

Name of School: …………………………………………………………

This posttest seeks to find out your understanding of IUPAC nomenclature of organic compounds. Please provide the responses in the spaces provided. Your performance will be used for research purposes only and will be highly confidential. You are therefore to respond to the items to the best of your ability. You will be given 1 hour to respond to the items after which your paper will be collected. Each answer to a sub question attracts 1mark

Consider the following organic compounds

A). $(CH_3)_2\ CHCH_2CHBrCH_2CH_3$

B). $C(CH_3)_2ICH(CN)\ CH_2CH_2CH_2CH(CH_3)CH_3$

C). $(CH_3)_2CHCH(CH_3)\ CH_2\ CC\ CH_2CH_2CH_3$

D). $CH_2CHCH_2CH(CH_3)CH_2CH_3$

E). $CH_3CH_2CH(CH_2CH_3)CH_2CF(C_2H_5)CH_2CHCH_2$

1. Indicate below the longest continuous carbon chain and the parent name in each of the above organic compounds labeled A, B, C, D and E.

	WRITE THE LONGEST CARBON CHAIN	GIVE THE PARENT NAME
A		
B		
C		
D		
E		

2. Indicate below the name of the substituent and their respective positions in each of the organic compounds labeled A, B, C, D, and E above.

	NAME OF SUBSTITUENT	POSITION OF THE SUBSTITUENT
A		
B		
C		
D		
E		

3. Name the functional groups present and their respective positions in each of the organic molecules labeled A, B, C, D and E above in the table below.

COMPOUND	NAME OF FUNCTION GROUP	POSITION OF THE FUNCTIONAL GROUP
A		
B		
C		
D		
E		

4. Draw below the structural formula for the condense formula for each of the hydrocarbon compounds labeled A, B, C, D and E above.

COMPOUND	STRUCTURAL FORMULAR
A	
B	
C	
D	
E	

5. Name each of the above compounds labeled A, B, C, D and E now.

COMPOUND	IUPAC NAME
A	
B	
C	
D	
E	

APPENDIX C

The general performance of students in the experimental class during the pretest assessment

Marks	0	1	2	3
LCCC	23	13	7	1
Parent Name	27	12	4	1
Substituent Name	30	9	4	1
Position of Substituent	30	8	5	1
Functional Group	35	7	1	1
Position of Functional Group	37	5	1	1
Structural Formula	28	12	3	1
IUPAC Name	37	5	1	1

The general performance of students in the control class during the pretest assessment

Marks c	0	1	2	3
LCCC	25	15	2	0
Parent Name	26	13	3	0
Substituent Name	25	8	9	0
Position of Substituent	27	12	3	0
Functional Group	34	7	1	0
Position of Functional Group	35	7	0	0
Structural Formula	23	16	3	0
IUPAC Name	33	7	2	0

APPENDIX D

Percentage distribution of students from the control class who obtain a particular mark for each of the test items.

Category questions	Mark (0)	Mark (1	Mark (2	Mark (3	Mark (4)	Mark (5)
Longest conti. Carbon chain	23.8	16.7	4.8	11.9	19.0	23.8
Parent Name	14.3	19.0	7.1	16.7	16.7	26.2
Substituent Name	28.6	14.3	16.7	19.0	2.4	19.0
Position of Substituent	45.2	14.3	4.8	16.7	9.5	9.5
Functional Group	26.2	16.7	26.2	7.1	16.7	7.1
Position of Functional Group	33.3	23.8	31.0	2.4	7.1	2.4
Structural Formula	26.2	9.5	26.2	4.8	23.8	9.5
IUPAC Name	45.2	21.4	19.0	4.8	2.4	7.1
Average percentages	30.35	16.96	16.98	10.43	12.20	13.08

Percentage distribution of students from the experimental class who obtain a particular mark for each of the test items.

Category questions	Mark (0)	Mark (1)	Mark (2)	Mark (3)	Mark (4)	Mark (5)
Longest conti. Carbon chain	4.5	6.8	18.2	18.2	13.6	38.6
Parent Name	6.8	9.1	20.5	11.4	18.2	34.1
Substituent Name	25.0	13.6	11.4	6.8	15.9	27.3
Position of Substituent	31.8	18.2	4.5	13.6	11.4	20.5
Functional Group	20.5	18.2	15.9	13.6	4.5	27.3
Position of Functional Group	31.8	13.6	22.7	6.8	9.1	15.9
Structural Formula	6.8	13.6	18.2	6.8	15.9	38.6
IUPAC Name	45.5	9.1	11.4	4.5	11.4	18.2
Average percentages e	21.6	12.8	15.4	10.2	12.5	27.6

APPENDIX E

Frequency distribution of marks in the posttest by the control class

Marks	**0**	**1**	**2**	**3**	**4**	**5**
LCCC	10	7	2	5	8	10
Parent Name	6	8	3	7	7	11
Substituent Name	12	6	7	8	1	8
Position of Substituent	19	6	2	7	4	4
Functional Group	11	7	11	3	7	3
Position of Functional Group	14	10	13	1	3	1
Structural Formula	11	4	11	2	10	4
IUPAC Name	19	9	8	2	1	3

Frequency distribution of marks in the posttest by the experimental class

Marks	**0**	**1**	**2**	**3**	**4**	**5**
LCCC	2	3	8	8	6	17
Parent Name	3	4	9	5	8	15
Substituent Name	11	6	5	3	7	12
Position of Substituent	14	8	2	6	5	9
Functional Group	9	8	7	6	2	12
Position of Functional Group	14	6	10	3	4	7
Structural Formula	3	6	8	3	7	17
IUPAC Name	20	4	5	2	5	8

APPENDIX F

Frequency distribution of marks in the posttest by the boys in the experimental clas

Marks	**0**	**1**	**2**	**3**	**4**	**5**
LCCC	2	2	3	6	2	15
Parent Name	2	3	3	4	6	12
Substituent Name	9	4	3	0	5	9
Position of Substituent	11	6	0	5	2	6
Functional Group	7	8	1	5	2	7
Position of Functional Group	12	2	9	2	1	4
Structural Formula	3	5	3	1	7	11
IUPAC Name	13	3	3	2	4	5

Frequency distribution of marks in the posttest by the girls in the experimental clas

Marks	**0**	**1**	**2**	**3**	**4**	**5**
LCCC	0	1	5	2	4	2
Parent Name	1	1	6	1	2	3
Substituent Name	2	2	2	3	2	3
Position of Substituent	3	2	2	1	3	3
Functional Group	2	0	6	1	0	5
Position of Functional Group	2	4	1	1	3	3
Structural Formula	0	1	5	2	0	6
IUPAC Name	7	1	2	0	1	3

APPENDIX G

Percentage frequency distribution of marks by the **boys** during the posttest in th

experimental class

Marks	**0**	**1**	**2**	**3**	**4**	**5**
LCCC	6.7	6.7	10.0	20.0	6.7	50.0
Parent Name	6.7	10.0	10.0	13.3	20.0	40.0
Substituent Name	30.0	13.3	10.0	0.0	16.7	30.0
Position of Substituent	36.7	20.0	0.0	16.7	6.7	20.0
Functional Group	23.3	26.7	3.3	16.7	6.7	23.3
Position of Functional Gro	40.0	6.7	30.0	6.7	3.3	13.3
Structural Formula	10.0	16.7	10.0	3.3	23.3	36.7
IUPAC Name	43.3	10.0	10.0	6.7	13.3	16.7

Percentage frequency distribution of marks by the **girls** during the posttest in the experimental class

Marks	**0**	**1**	**2**	**3**	**4**	**5**
LCCC	0.0	7.1	35.7	14.3	28.6	14.3
Parent Name	7.1	7.1	42.9	7.1	14.3	21.4
Substituent Name	14.3	14.3	14.3	21.4	14.3	21.4
Position of Substituent	21.4	14.3	14.3	7.1	21.4	21.4
Functional Group	14.3	0.0	42.9	7.1	0.0	35.7
Positio. of Functional Grouր	14.3	28.6	7.1	7.1	21.4	21.4
Structural Formula	0.0	7.1	35.7	14.3	0.0	42.9
IUPAC Name	50.0	7.1	14.3	0.0	7.1	21.4

APPENDIX H

Marking scheme for pretest and posttest

PRETEST ON IUPAC NOMENCLATURE OF ORGANIC COMPOUNDS

Biographic Data

Gender: Male [ ] Female [ ] Age [ ]

Name of School: …………………………………………………………….

This pretest seeks to find out your understanding of IUPAC nomenclature of organic compounds. Please provide the responses in the spaces provided. Your performance will be used for research purposes only and will be highly confidential. You are therefore to respond to the items to the best of your ability. Use 40 minutes to respond to the items after which your paper will be collected. Each answer to a sub question attracts 1mark

Consider the following organic compounds

A). $(CH_3)_3$ $CCHCHCH_3$

B). $CH_3C(CH_3)_2CHBrCH(CH_3)CH_3$

C). $(CH_3)_2CHCH(CH_3)CCCH_2CH_3$

1. Indicate below the longest continuous carbon chain and the parent name in each of the above organic compounds labeled A, B and C.

Compound	Longest continuous carbon chai	Parent name
A	5	Pent
B	5	Pent
C	7	Hept

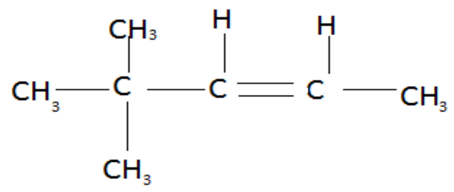
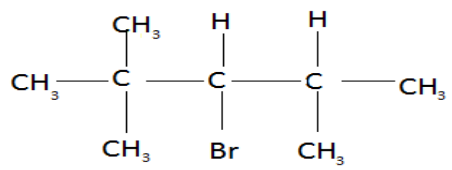
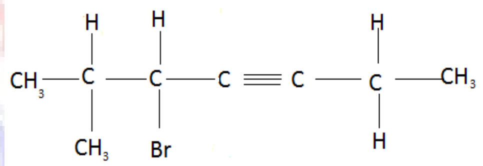
2. Indicate below the name of the substituent and their respective positions in each of the organic compounds labeled A, B and C above.

Compound	Substituent/s	Position of substituent
A	methyl, methyl	4,4
B	bromo, methyl,methyl,methyl	3,2,2,4
C	Methyl,methyl	5,6

3. Name the functional groups present and their respective positions in each of the organic molecules labeled A, B and C above in the table below.

Compound	Functional groups	Position of functional groups
A	Alkene	2
B	Nil	-
C	Alkynes	3

4. Draw below the structural formula for the condense formula for each of the hydrocarbon compounds labeled A, B and C above.

Compound	Structural formula
A	
B	
C	

5. Name each of the above compounds labeled A, B and C now

COMPOU	IUPAC NAME
A	4,4-dimethyl-2-pentene
B	3-bromo-2,2,4-trimethylpentane
C	5,6-dimethyl-3-heptyne

POSTTEST ON IUPAC NOMENCLATURE OF ORGANIC COMPOUNDS

Biographic Data

Gender: Male [ ] Female [ ] Age [ ]

Name of School: ……………………………………………………….

This posttest seeks to find out your understanding of IUPAC nomenclature of organic compounds. Please provide the responses in the spaces provided. Your performance will be used for research purposes only and will be highly confidential. You are therefore to respond to the items to the best of your ability. You will be given 1 hour to respond to the items after which your paper will be collected. Each answer to a sub question attracts 1mark

Consider the following organic compounds

A). $(CH_3)_2\ CHCH_2CHBrCH_2CH_3$

B). $C(CH_3)_2ICH(CN)\ CH_2CH_2CH_2CH(CH_3)CH_3$

C). $(CH_3)_2CHCH(CH_3)\ CH_2\ CC\ CH_2CH_2CH_3$

D). $CH_2CHCH_2CH(CH_3)CH_2CH_3$

E). $CH_3CH_2CH(CH_2CH_3)CH_2CF(C_2H_5)CH_2CHCH_2$

1. Indicate below the longest continuous carbon chain and the parent name in each of the above organic compounds labeled A, B, C, D and E.

	WRITE THE LONGEST CARBO CHAIN	GIVE THE PARENT NAME
A	6	Hex
B	7	Hept
C	9	Non
D	6	Hex
E	8	Oct

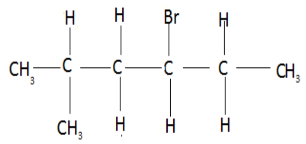
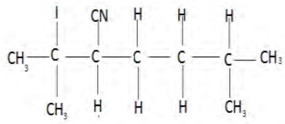
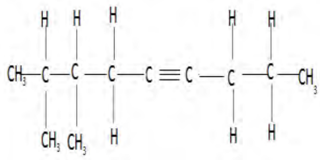
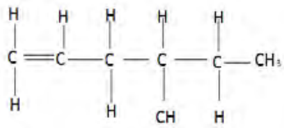
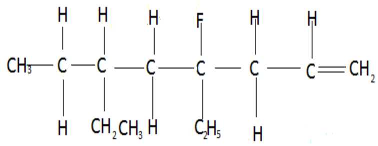
2. Indicate below the name of the substituent and their respective positions in each of the organic compounds labeled A, B, C, D, and E above.

	NAME OF SUBSTITUENT	POSITION OF THE SUBSTITUENT
A	Bromo, methyl	4,2
B	Cyano, iodo, methyl, methyl	3,2,2,6
C	Methyl, methyl	7,8
D	Methyl	4
E	Flouro, ethyl, ethyl,	4,4,6

3. Name the functional groups present and their respective positions in each of the organic molecules labeled A, B, C, D and E above in the table below.

COMPOUND	NAME OF FUNCTION GROUP	POSITION OF THE FUNCTIONAL GROUP
A	Nil	-
B	Nil	-
C	Alkyne	4
D	Alkene	1
E	Alkene	1

4. Draw below the structural formula for the condense formula for each of the hydrocarbon compounds labeled A, B, C, D and E above.

COMPOUND	STRUCTURAL FORMULAR
A	
B	
C	
D	
E	

5. Name each of the above compounds labeled A, B, C, D and E now.

COMPOUND	IUPAC NAME
A	4-bromo-2-methylhexane
B	3-cyano-2-iodo-2,6-dimethylheptane
C	7,8-dimethyl-4-nonyne
D	4-methyl-1-hexene
E	4-flouro-4,6-diethyl-1-octene

APPENDIX I

LESSON PLAN

TOPIC: IUPAC SYSTEM OF NAMING ORGANIC COMPOUNDS.

PRESENTED BY: GERSHON KWAKU WOSOR**.**

CLASS: Form two sciences A and B.

TIME: 7:30am - 8:45am, 9:15am – 10:30am respectively.

DAY/ DURATION	TOPIC/ SUBTOPIC	OBJECTIVES /RPK	TEACHER-LEARNER ACTIVITIES/ TEACHING LEARNING MATERIALS	CORE POINTS	EVELUATION AND REMARKS
WED, 14TH OCTOBER, 2015 (1HR, 15MIN)	Organic Compounds/ IUPAC system of naming organic compounds.	**OBJECTIVES** By the end of this lesson, students should be able to: 1. Draw the structure formula of organic compounds when the condense ormula of the molecule is given. 2. Name organic compounds when the condense formula is given. **RPK** 1. The students know what functional groups are. 2. The types of substituent's we have: organic and inorganic substituent. 3.The number of bonds each element can for especially carbon atom.	Teacher 1. States all the rules regarding naming of organic compounds 2 Draw the structure of three condense formula compounds and name them. Students from the control class also repeat it for several other organic compounds. 3. Model the structures of three condense formula compounds and name them. Students from the experimental class also repeat it for several other organic compounds.	1. Count the **longest continuous chain (LCCC)** and name it as the structure. 2. Any group that does not form par LCCC is a substituent 3. Indicate the position of the subst inorganic first follow by substituents all in alphabetical order	Draw the structure of the following compounds and name them. a).$CH_3)_2CHCH_2CHBrCH_3$ B). $C(CH_3)_2ICH(CN)CH_2CH_2CH(CH_3)$