

# Identifying Students' Misconceptions in IUPAC Nomenclature of Organic Compounds in Public Senior Secondary Schools in Ibadan, Nigeria

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## ABSTRACT

The ability to accurately name organic compounds according to IUPAC rules is fundamental in chemistry education. Nevertheless, recent studies indicate students' misconceptions in this regard. A qualitative research design involving 56 respondents was employed. The instruments for the study are the Students' Perception Scale in IUPAC Nomenclature ( $r = 0.80$ ) and the IUPAC Nomenclature Diagnostic Test ( $r = 0.71$ ). The result showed mixed perceptions of students in this regard. Among the identified students' misconceptions in naming organic compounds are poor knowledge of the parent chain, inability to make sense of substituents, functional groups, isomerism, alkyl groups, etc. Students' misconceptions in this regard could have a negative implication on their achievement. The teacher could identify and address those misconceptions through innovative strategies and regular feedback. Diagnosing such difficulties would help educators and policymakers work together to develop targeted support systems, improve teaching methods, and promote student success in chemistry.

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## 1. INTRODUCTION

Chemistry education seeks to assist students in comprehending the material world and natural processes, significantly aiding human development, sustainability, and national progress. Chemistry is categorized into various branches, including physical chemistry, inorganic chemistry, analytical chemistry, and organic chemistry. Organic chemistry is a field of study in both secondary schools and higher education institutions. Organic chemistry focuses on the examination of hydrocarbons. Hydrocarbons are organic compounds that are made up of carbon and hydrogen, and this is reflected in their names. The study of hydrocarbons is important in fields such as biology, agricultural science, and medicine, but more importantly, chemistry. Hydrocarbons are divided into two main

categories: aliphatic and aromatic hydrocarbons. One of the fundamental concepts in studying organic chemistry is the IUPAC naming of organic compounds.

According to Hellwich et al. [1], IUPAC is the universally recognized authority on chemical nomenclature and terminology. The organized system for naming organic compounds is referred to as IUPAC nomenclature. The International Union of Pure and Applied Chemistry (IUPAC) developed a method for naming organic compounds, known as IUPAC nomenclature in chemistry. This system connects the names of compounds to their molecular formulas. Each name consists of a root, a suffix, and prefixes. The root typically represents an aliphatic hydrocarbon. The naming of organic compounds starts from the root hydrocarbon by appending a suffix and prefixes to indicate the replacement of hydrogen atoms. A suffix is attached to the root to signify the presence of the main substituent, which is often the principal functional group in the molecule. Prefixes are used for cyclic compounds to name them, such as cyclohexane [2]. According to Taylor et al. [3], there are three methods for naming organic compounds: the Lewis structure (also known as the expanded structural formula), which displays all carbon and hydrogen atoms along with any other atom or group of atoms, and the covalent bonds linking them. The second method, the condensed structural formula, illustrates the carbon atoms in the linear chain along with any other atoms or groups connecting to the chain, omitting the covalent bonds or unshared electron pairs. The third approach is the line-angle drawing, which utilizes lines to represent chemical bonds without showing carbon and hydrogen atoms.

To name organic compounds successfully, a set of rules must be followed. The guidelines for naming organic compounds according to IUPAC are: number the longest continuous carbon chain no matter the direction of the carbon atoms; start naming from the side closest to the substituent, e.g., alkyl group, chloro, hydroxyl, etc., if there is a functional group in a compound, naming starts from the side closest to the functional group as the functional group is given precedence over substituent, i.e., the functional group should always be numbered first with the least possible figure; if two or more compound of the same substituents appear in a compound, the number is indicated by di- for 2, tri-for 3, tetra-for 4, etc. Commas are separate numbers, and letters are separated from numbers by hyphens, e.g., 2,2-dimethyl butane; if there are two or more alkyl groups attached to the parent chain, name them in alphabetical order. The IUPAC nomenclature is vital in naming organic compounds as it aids in identifying the elemental components of a compound in relation to functional groups, substituents, and degrees of saturation and unsaturation, among other factors. According to Williams, understanding IUPAC nomenclature can significantly alleviate students' challenges in organic chemistry, as it equips them with the skills to construct structures of various organic compounds and assign them proper names.

The IUPAC nomenclature reveals the primary properties of compounds, making it extremely helpful in both organic and inorganic chemistry. For example, 2,2-dimethyl pentane indicates that the parent molecule, also known as pentane with five carbon atoms, contains two methyl substituents and is unsaturated. The nomenclature of organic compounds is a basic concept in learning organic chemistry. However, it has been reported in the literature that students have a series of difficulties with IUPAC nomenclature; these difficulties have been termed as misconceptions [4]. Students' difficulties in this regard

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could be linked to cognitive, pedagogical, and representational challenges. Students do not enter the class as empty vessels but rather have preconceived notions or understanding of the science subjects that the teacher will teach, and misconceptions can be categorized into prior ideas, misconceptions, and alternative conceptions [5]. By implication, pre-existing knowledge, which has to do with their previous information, experiences, and beliefs, can significantly impact students' learning outcomes by building new information upon existing knowledge. It could affect students' perceptions, motivation, and engagement as they may be feeling more confident in their pre-existing knowledge. In line with Johnson [6], misconceptions could be regarded as preconceived notions, non-scientific beliefs, naive theories, muddled conceptions, or conceptual misunderstandings. In general, there are situations in science where people's views may differ from what is scientifically possible. These have led to a number of misconceptions about different topics, which have been negatively impacting their progress. According to Mistry et al. [7] and Raker et al. [8], a significant issue is the poor performance of chemistry students at the Senior Secondary School level. Many educators have theorized that this is due to misunderstandings about some aspects of the chemistry curriculum [6], [9], [8]. Also, Anim et al. [10] noted that students demonstrated conceptual difficulties in various concepts of organic chemistry.

According to Ukah et al. [4], students have a number of misconceptions regarding IUPAC terminology. In a similar vein, Salame and Khalil [11] stated that students struggle to learn about the mechanisms underlying the rearrangement of responses and rely on rote learning and memorization, which impedes the development of conceptual understanding. Among other things, IUPAC nomenclature and isomerism have been identified as concepts that students find challenging [12], [13], [14]. According to Martin [9], students have difficulties in naming structural formulae of branched- and substituted-chains of alkanes and alkenes, geometrical isomers, dienes, unbranched alkynes, primary and tertiary alkanols, diols, alkanolic acids, and alkyl alkanooates. WAEC [15] reports reveal students' misconceptions about the IUPAC nomenclature of organic compounds. Similarly, Patel [16] advanced that chemistry students performed very weakly in the IUPAC nomenclature of organic compounds. Martin [9] found that chemistry students struggle with IUPAC nomenclature in a variety of ways, including their inability to identify the correct number of atoms in an organic compound, their inability to understand functional groups, their inability to question substituents in branched-chain compounds, their inability to name the parent chain, their inability to identify branched-chain and substituted-chain of alkanes, and their inability to understand the right suffix for identical functional groups and multiple bonds. In a similar vein, Martin [9] found that students performed poorly when it came to IUPAC nomenclature for organic molecules.

Addressing these misconceptions will improve students' achievement not only in IUPAC nomenclature but also in chemistry as a whole. Addressing these misconceptions is an advantage to students who may take advanced courses in chemistry [9]. Learning IUPAC nomenclature will provide a universal language for chemists to communicate chemical information accurately and unambiguously [17]. In resonance with Johnson [6], learning IUPAC nomenclature helps students understand the structure and properties of

chemical compounds, which is crucial for predicting their behavior and reactivity. Williams [18] established that learning IUPAC nomenclature improves students' retention of chemical information, as it provides a systematic and logical approach to naming compounds. Mastering IUPAC nomenclature can increase students' confidence in their ability to communicate chemical information, which is essential for success in chemistry and related fields [19]. In a recent study by Reyes et al. [5], it was found that students who learned IUPAC nomenclature showed improved performance in organic chemistry exams compared to those who did not receive explicit instruction. Another study by Patel [16] found that using online resources to learn IUPAC nomenclature improved students' understanding and retention of chemical nomenclature. According to Taylor [3], learning IUPAC nomenclature could improve students' problem-solving ability.

Emphasizing the need to address students' misconceptions in naming organic compounds, the study, therefore, identified students' misconceptions of IUPAC nomenclature of organic compounds in public senior secondary schools in Ibadan, Nigeria, by carrying out diagnostic-based research in IUPAC nomenclature of organic compounds.

### **Statement of Problem**

IUPAC nomenclature of organic compounds is the naming of organic compounds by following a set of rules. It improves students' knowledge about organic compounds. It cuts across every other aspect of organic chemistry. Other aspects of organic chemistry make use of IUPAC nomenclature. It is a fundamental requirement in understanding organic chemistry. It is required in natural products, organic synthesis, organic spectroscopy, and reaction mechanisms, among others. However, it has been established in the literature that students find it difficult to name organic compounds. Reasons for this difficulty have been ascribed to various misconceptions of students in this regard. In order to address this situation, various authors have worked on different methods of teaching it with little or no emphasis on diagnosing students' misconceptions in this regard. Some authors identified various variables that could be responsible for students' poor performance in IUPAC nomenclature. It is against this background that this study diagnosed students' misconceptions about IUPAC nomenclature among secondary school students in the Egbeda Local Government Area of Ibadan, Nigeria.

### **Research Question**

To identify students' challenges with the IUPAC nomenclature of organic compounds, the study provided answers to the following questions:

- a. What is the perception of students about IUPAC naming in organic chemistry?
- b. What are the students' difficulties in the IUPAC nomenclature of organic compounds?

## **2. METHOD**

### **2.1. Research Design**

The study adopted a qualitative survey approach to identify students' misconceptions about the IUPAC nomenclature of organic compounds. In order to ensure that individual students have an equal chance of being selected, one (1) local government area was chosen at random from eleven (11) local government areas. Intact classes of one

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(1) public senior secondary school and (I) science class were chosen at random. In order to identify students' misconceptions about the IUPAC nomenclature of organic compounds, a diagnostic test was first administered and graded, and the curve for the class score was plotted. The students in the upper bound scored between 6-10 marks, and there were 21 in number. The students in the lower bound scored between 0-5, and there were 35 in number. From the upper bound and the lower bound, 10 respondents were randomly selected to ensure that there was no bias in the selection and that their responses were content analyzed.

**Research instruments:** two research instruments were utilized for the study.

a. **Students' Perception Scale in IUPAC Nomenclature (SPSIN):**

This instrument was developed by the researcher to better understand students' perceptions of organic compound naming according to the IUPAC. The instrument contains two sections; section A collected information about the demographics of the respondents. Section B contains ten (10) test items on a two-point Likert scale of Yes and No.

**Validity and Reliability:** The validity of the SCKBCE was guaranteed during the development phase. KR20 was used to calculate the reliability coefficient, and a reliability coefficient of 0.80 was determined.

**Scoring:** SPSIN was ranked as YES and NO, YES=2, NO=1

b. **IUPAC Nomenclature Diagnostic Test (INDT):**

This is a self-made diagnostic test called INOCDT, which was developed specifically for this study to identify students' misconceptions of the IUPAC nomenclature of organic chemicals. It has two sections: section A gathers the demographics of the respondents, while section B contains ten (10) diagnostic test items.

**Validity and Reliability:** During the construction phase, expert consultation was guaranteed to ensure the content validity of the instrument. To determine the reliability coefficient using test-retest analysis, the instrument was initially given to ten (10) SS III science students from a different school from the one where the research was conducted. When the test was given to the same group of students again two weeks later, the reliability coefficient of the instrument was found to be 0.71.

**Scoring:** Students' responses were marked as either right or wrong.

### 2.3. Procedure

The steps in the procedure include visiting the school chosen for the study to obtain permission from the school administration to conduct the study there, and then, with the assistance of the school's chemistry teacher, administering the test items and collecting the test results from the students.

### 2.4 Data Analysis

Frequency distribution counts were used to assess the student perception data, and content analyses were performed on the diagnostic instrument data.

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### 3. RESULTS AND DISCUSSION

#### 3.1. Result

##### *What is the perception of students about IUPAC naming in organic chemistry?*

Table 1 presents the frequency distribution of students based on their perceptions of IUPAC nomenclature of organic compounds as follows: I can name organic compound: 9(90%), 1(10%); It is difficult to name organic compounds: 8(80%), 2(2%); IUPAC nomenclature is not difficult: 8(80%), 2(2%); I cannot name organic compounds: 9(90%), 1(10%); Rules for IUPAC nomenclature are difficult: 8(80%), 2(2%); Rules for IUPAC nomenclature are not difficult: 6(60%), 4(40%); I find IUPAC nomenclature difficult 3(30%), 7(30%); Organic compounds are difficult to name: 1(10%), 9(90%); It is not necessary to follow rules in naming organic compounds: 1(10%), 9(90%); I can recall those rules when naming organic compounds: 4(40%), 6(60%).

Table 1. Frequency Distribution of Students based on their Perception of IUPAC naming of Organic Compounds

S/N	Item	Yes	No
1.	I can name an organic compound	9(90%)	1(10%)
2.	It is not easy to name organic compounds	8(80%)	2(2%)
3.	IUPAC nomenclature is not difficult	8(80%)	2(2%)
4.	I cannot name organic compounds	9(90%)	1(10%)
5.	Rules for IUPAC nomenclature are difficult	8(80%)	2(2%)
6.	Rules for IUPAC nomenclature are not difficult	6(60%)	4(40%)
7.	I find IUPAC nomenclature difficult	3(30%)	7(30%)
8.	Organic compounds are difficult to name	1(10%)	9(90%)
9.	It is not necessary to follow rules in naming organic compounds	1(10%)	9(90%)
10.	I can recall those rules when naming organic compounds	4(40%)	6(60%)

YES = 2, NO = 1

##### *What are the identified students' misconceptions in the IUPAC nomenclature of organic compounds?*

Table 2 presents the frequency distribution of students based on their misconceptions of IUPAC nomenclature as follows: 40% of the respondents manifest misconception in making sense of the parent chain of organic compounds; 300% of the students could not interrogate organic compounds to make sense of substituents in IUPAC naming; 70% of the students could not make sense of the functional groups and substituents in IUPAC naming; 70% of the respondents do not understand alkyl group; 50% of the students exhibit misconception in isomerism; 60% of the students manifest difficulties in naming organic compounds correctly; 70% of the students could not write the structural formula of organic compounds; 70% of the respondents exhibited difficulties in differentiating between a cyclic and acyclic compounds; 70% of them could not differentiate between cycloalkane and cycloalkyne; 60% of the respondents could not carbon atom of organic compounds correctly.

Table 2. Percentage Distribution of Students based on their Misconceptions in IUPAC Nomenclature

S/N	Concept	Right	Wrong	No Response	Remark
1.	Parent Chain	5(50%)	4(40%)	1(10%)	Moderate
2.	Compounds containing substituents (Alkyl and halogens)	7(70%)	3(30%)	0(0%)	Low
3.	The compound containing functional groups and substituents	3(30%)	7(70%)	0(0%)	High
4.	Alkyl group	3(30%)	7(70%)	0(0%)	High
5.	Isomerism	7(1%)	3(80%)	0(0%)	High
6.	Correct naming of organic compounds	4(80%)	6(60%)	0(0%)	High
7.	Structural formula	3(30%)	7(70%)	0(0%)	High
8.	Differences between cyclic and acyclic	3(30%)	7(70%)	0(0%)	High
9.	Naming of cycloalkane and cycloalkyne	3(30%)	7(70%)	0(0%)	High
10.	Numbering of Carbon Atoms	2(20%)	6(60%)	0(0%)	High

### 3.2. Discussion

#### Students' Perceptions in IUPAC nomenclature of organic compounds

Based on the result of the analysis of students' perception of IUPAC nomenclature, it is established that most students can name organic compounds, while most students said that they find it difficult to name organic compounds; a larger percentage of students said that IUPAC nomenclature is not difficult while nearly all the respondents affirmed that they could not name organic compounds; nearly all the students agreed that the rules for IUPAC nomenclature are difficult while few of them said that rules for IUPAC nomenclature are not difficult; nearly all the students said no to 'I find IUPAC nomenclature difficult'; most of the respondents disagree that organic compounds are difficult to name; most students agreed that It is necessary to follow rules in naming organic compounds; larger percentage of students said no to 'I can recall those rules when naming organic compounds'. Students' perceptions of IUPAC nomenclature in this study suggest that they have a number of misconceptions regarding the naming of organic compounds, which may significantly harm their chemistry performance. This is consistent with Patel [16], who found that students performed poorly on the IUPAC nomenclature of organic compounds. The expression of students' misunderstandings of IUPAC nomenclature is consistent with Martin [9], who noted that students struggle with IUPAC nomenclature. The result of this study aligns with various studies on students' difficulties in IUPAC nomenclature, where the majority of students' difficulties have been linked to various factors, among which misconception is included [6], [16], [20].

## Students' Misconceptions in IUPAC Nomenclature of Organic Compounds

This study identified ten (10) misconceptions of students in the nomenclature of organic compounds, and they are discussed under the following headings:

### a. Misconceptions about the Number of Carbon Atoms in the Parent Chain in Organic Compounds

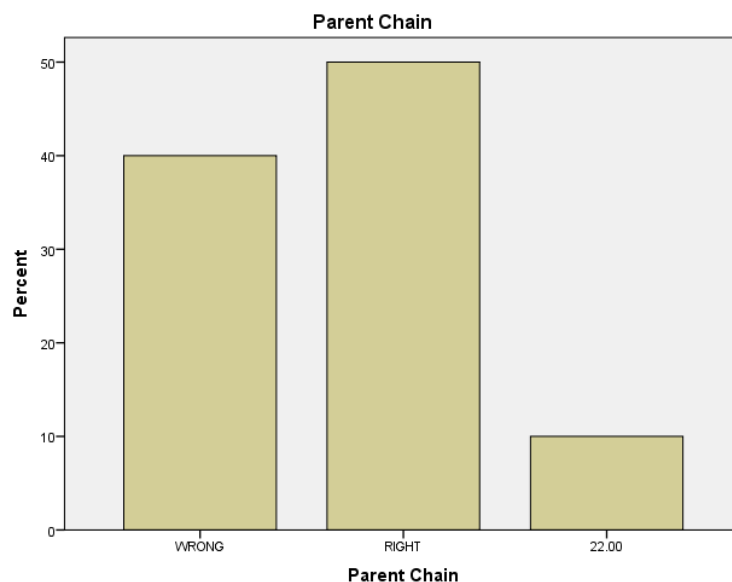


Figure 1. Misconceptions about the Number of Carbon Atoms in the Parent Chain in Organic Compounds

Figure 1 shows that not all the respondents gave the right answer to this question, and some of them did not provide answers to the question. By implication, the level of misconception students have about parent chains in naming organic compounds is moderate, according to Table 2. Students were asked to explain why naming  $CH_3-CH_2-CH_2-CHCH_3-CH_3$  as *4-methylhexane* is wrong or right. Some of them said the naming was correct, and some said the naming was wrong but failed to state categorically why the naming was wrong. Most students failed to state that the parent chain is pentane. Thus, it is named *2-methylpentane*. By implication, most students violated rule number one by exhibiting misconceptions about the parent chain in naming organic compounds and naming from the side closest to the substituent. This outcome is consistent with [8], who found that students' incapacity to correctly identify the number of carbon atoms in the parent chain was one of the challenges they had while naming organic compounds, according to IUPAC. This specific fallout may cause students to perform poorly in this area, which may hinder their comprehension of organic chemistry. This perspective is consistent with Patel [16], who found that high school students perform poorly when it comes to the IUPAC nomenclature of organic compounds. Similarly, Salame and Khalil [21] obtained that chemistry students face challenges in learning organic chemistry.

### b. Misconceptions about Substituents in Organic Compounds

Figure 2 shows that the level of misconception of students about this concept is very low. However, a small percentage of students exhibited misconceptions in this regard

when they were asked to name this compound:  $\text{CH}_3\text{CHCH}_3\text{CHCBr}_2\text{CHClCH}_3$ . According to Table 2, the level of misconception in this regard is very low. Among those who got the answer wrong were those who could not identify the methyl group attached as the substituent. Some did not understand that if two or more substituents appear in a compound, the number is indicated by di-2, tri-3, and tetra-4; as such,  $\text{Br}_2$  is named as dibromo. Those who could identify the functional groups could not name them alphabetically. For instance, instead of naming the compound **3-dibromo-2-chloro-4-methylpentane**, some of them wrote 4-methyl-2-chloro-3-methylpentane. By implication, students could not make sense of the substituents, such as alkyl and halogen, in the compound. As such, they violated two rules of IUPAC nomenclature; if two or more compounds of the same substituents appear in the compound, the number is indicated by *di- for 2, tri- for 3, tetra- for 4*, etc. Commas separate numbers and letters from numbers by hyphens, e.g., 2,2-dimethyl butane; if there are two or more alkyl groups attached to the parent chain, name them in alphabetical order. This finding resonates with Martin [9], Wang et al. [22], and Sunasee [23], who established that students have various misconceptions about the IUPAC nomenclature of organic compounds.

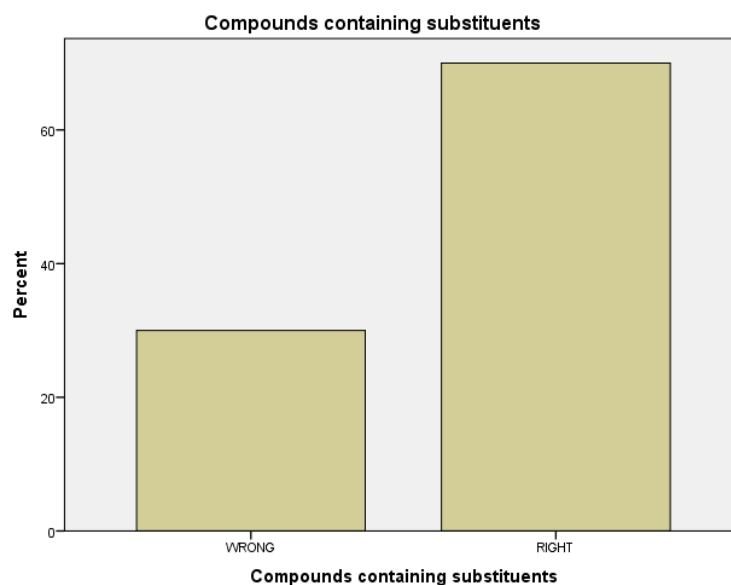


Figure 2. Misconceptions about Substituents in Organic Compounds

### c. Misconceptions about Functional Groups and Substituents

One of the rules of IUPAC naming says that if there is a functional group in a compound, start naming from the side closest to the functional group, as the functional group is given precedence over the substituent, i.e., the functional group should always be numbered first with the least possible figure. Figure 3 shows the percentage of students who violated this rule with a high level of misconception, and this is supported by Table 2. Students were asked to name this compound  $\text{CH}_3\text{CHCH}_3\text{CH}(\text{CH}_3\text{CH}_2)_2\text{CHOHCH}_3$ . Instead of students naming them as **3,3-diethyl-4-methylpentane**, some of them wrote 4-methyl-3,3-diethylpentane, which is the wrong name for the compounds. The result supports Anim et al. [24], who noted students' difficulties in detecting functional groups

containing compounds. This finding agrees with Anim and Adu [25], who established that students exhibit difficulties in the IUPAC nomenclature of organic compounds.

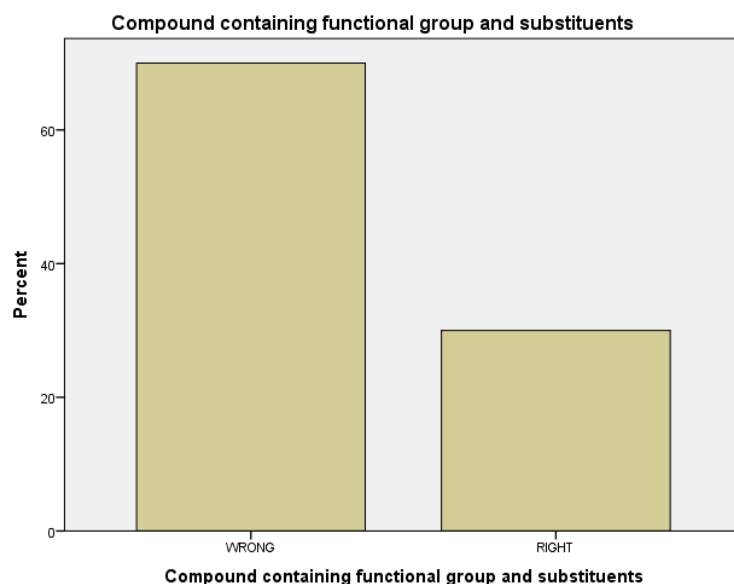


Figure 3. Misconceptions about Functional Groups and Substituents

#### d. Misconceptions about Alkyl Groups

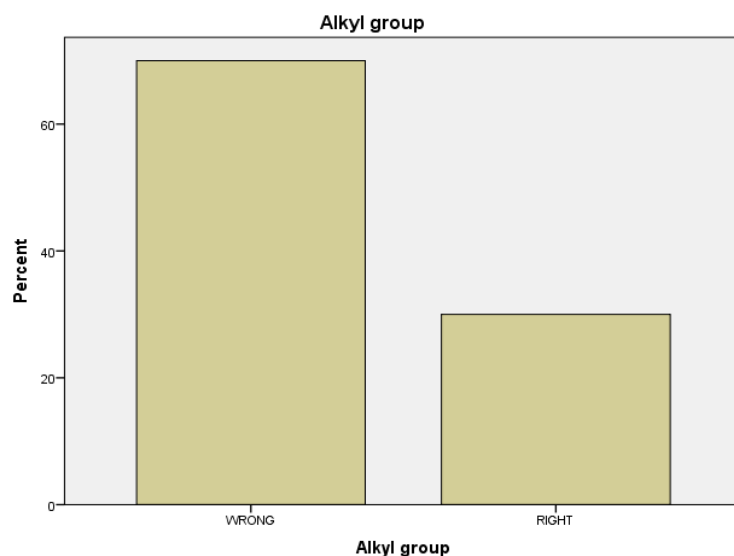


Figure 4. Misconceptions about Alkyl Groups

Figure 4 shows a larger percentage of students exhibiting high levels of misconception about the alkyl group, and Table 2 shows that the level of misconception is very high. Students were asked to name  $CH_3$ ,  $C_2H_5$ ,  $C_3H_{11}$ , and  $C_6H_{13}$ . Virtually all the students gave the wrong names for the compounds. At some point, students were asked to differentiate between  $C_2H_5$  and  $C_2H_6$ . Instead of explaining that  $C_2H_5$  is a derivative of  $C_2H_6$  and naming them as *ethyl and ethane*, respectively, they wrote incorrect names. This is an indication that students have misconceptions about the alkyl group. The result agrees with

Anim and Adu [25], Martin [9], Wang et al. [22], and Sunasee [23], who revealed in their study that the students held similar misconceptions in chemistry as those found in Western countries.

#### e. Misconception about Isomerism

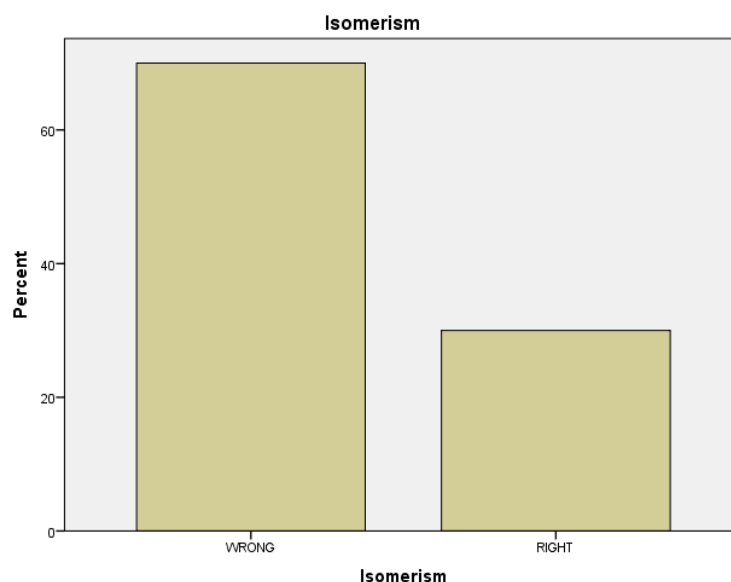
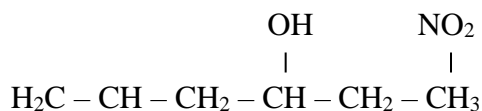


Figure 5. Misconception about Isomerism

Figure 5 shows that students exhibit misconceptions about this concept. Table 2 also indicates a high level of misconception in this regard. Students were asked to differentiate between  $\text{CH}_2\text{CHCH}_2\text{CH}_3$  and  $\text{CH}_3\text{CH}_2\text{CHCH}_3$ . Instead of stating that the two compounds are isomers, the students wrote a series of incorrect names. Also, the students failed to write down the possible isomers of  $\text{C}_5\text{H}_{12}$ . By implication, students have manifested difficulty with isomerism, and it means that they have misconceptions about isomerism. This result also corroborates Grove and Lowery [26], Martin [9], Wang et al. [22], and Sunasee [23], who established that students have misconceptions about organic chemistry.

#### f. Misconceptions about the Naming of Organic Compounds

Figure 6 shows the percentage of respondents who manifested a misconception in this regard. Similarly, Table 2 shows a high level of misconception about this concept. When students were asked to name:



Only a few of the respondents could not name this compound. By implication, the level of misconception among students about the naming of organic compounds with substituents is low. This finding also agrees with Salame and Khalil [21], Grove and Lowery [26], Martin [9], Wang et al. [22], and Sunasee [23], who established students' misconceptions

in chemistry. This is similar to the naming of organic compounds, where most students could not name organic compounds correctly.

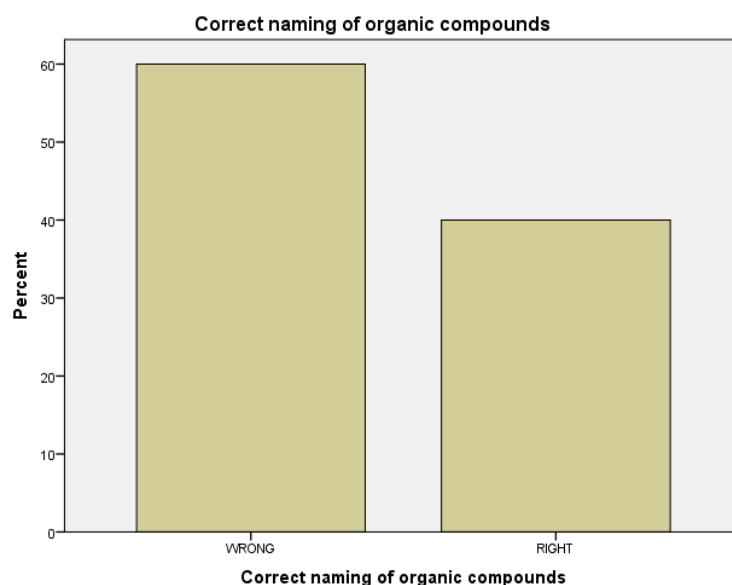


Figure 6. Misconceptions about the Naming of Organic Compounds

#### g. Structural Formula

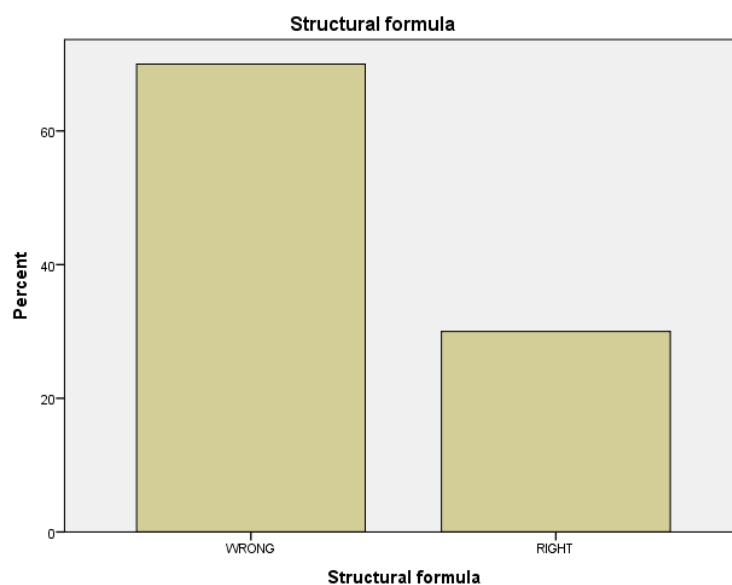


Figure 7. Structural Formula

Figure 7 shows the inadequacy of students in writing the structural formula of organic compounds, and this is evidence of students' misconceptions in this regard. Table 2 shows that the level of misconception in this regard is also high. This was evident when students were asked to draw the structure and write the structural formula of *1,1-dimethyl, 2-ethylprop-2-ene*. Only a few of the students could not perform this task. By implication, students, the category of students who could not draw and write the structure, are said to

have misconceptions in this regard. The result aligns with [25], who established that students could not give correct chemical structures to organic compounds undergoing chemical reactions. It also supports Anim and Adu [24], Salame and Khalil [21], Martin [9], and Asipita et al. [20], who also established students' misconceptions about chemistry. According to Salame and Khalil [21], students have a poor understanding of Lewis structures of organic chemistry.

#### h. Misconception about cyclic and acyclic compounds

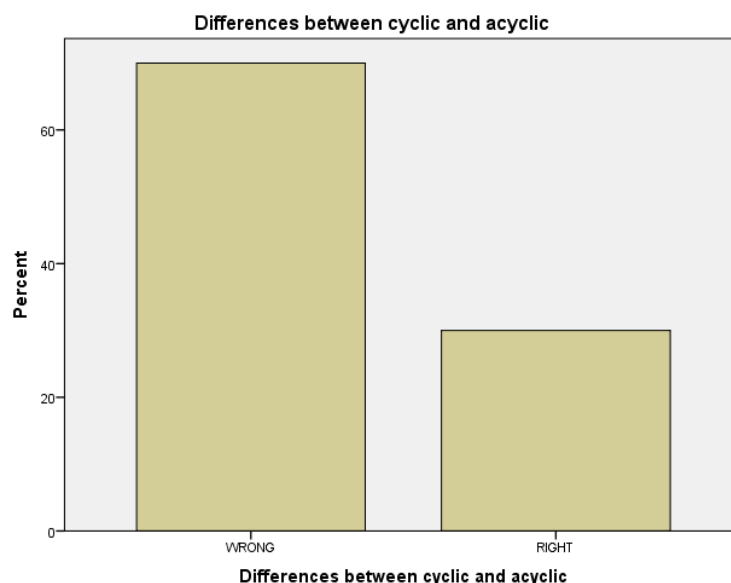


Figure 8. Misconception about cyclic and acyclic compounds

Figure 8 shows that most of the students manifest misconceptions when identifying cyclic and acyclic compounds; as such, students cannot differentiate between cyclic and acyclic compounds. This misconception is also presented in Table 2 as being too high. When students were asked to differentiate between  $C_2H_2$  and  $C_6H_6$  in terms of their classes, a larger percentage of them could not identify  $C_2H_2$  as acyclic and  $C_6H_6$  as cyclic. The students' level of misconception about this concept is somewhat high, as the majority of them could not differentiate between cyclic and acyclic compounds. The results resonate with the findings of Anim and Adu [25], Martin [9], Wang et al. [22], Sunasee [23], and Anim and Adu [24], who posited that secondary school students have various misconceptions about organic chemistry.

#### i. Misconception about Cycloalkane and Cycloalkyne

Figure 9 shows that the percentage of students who could not differentiate between cycloalkane and cycloalkyne is very high, and Table 2 also indicates a high level of misconception in this regard. Students were asked to differentiate between cycloalkane and cycloalkyne, but most students failed to differentiate between cycloalkane and cycloalkyne. This result is in line with Martin [9], who advanced that students have difficulties in naming structural formulae of branched- and substituted-chains of alkanes and alkenes, geometrical isomers, dienes, unbranched alkynes, primary and tertiary

alkanols, diols, alkanolic acids, and alkyl alkanoates. Also, it resonates with WAEC [15], who reported students' misconceptions about the IUPAC nomenclature of organic compounds.

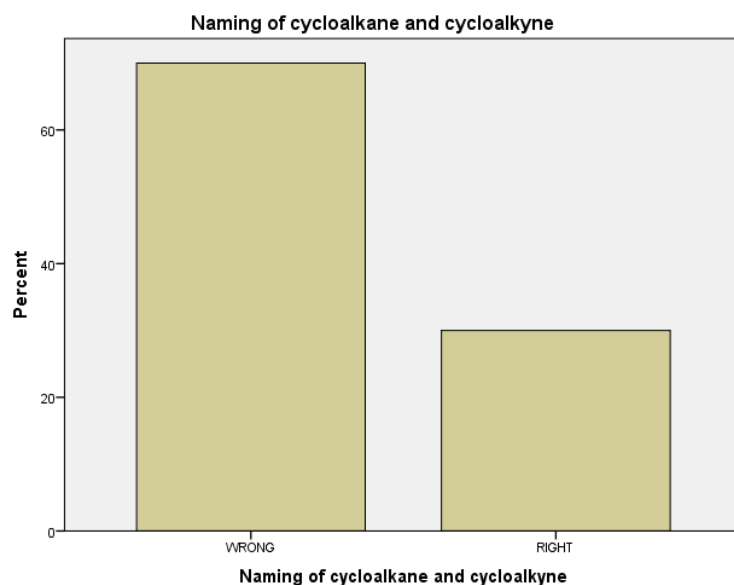


Figure 9. Misconception about Cycloalkane and Cycloalkyne

#### j. Misconception about the Numbering of Carbon Atoms

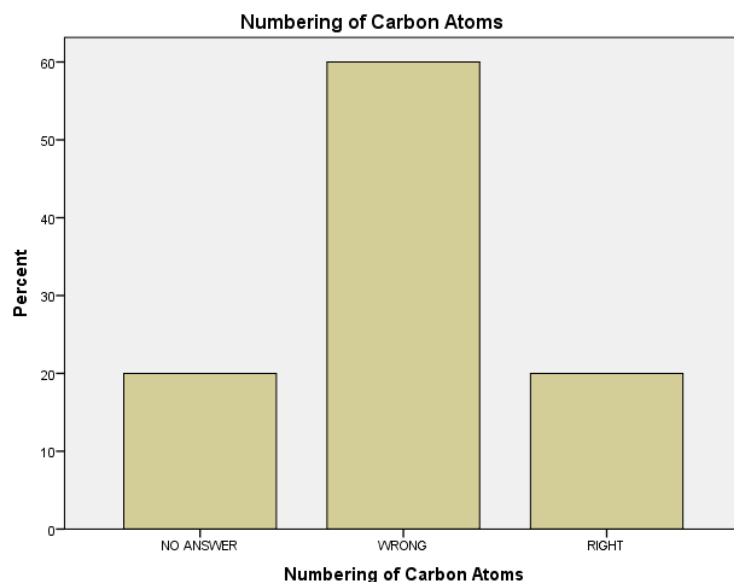


Figure 10. Misconception about the Numbering of Carbon Atoms

Figure 10 shows that the level of misconception students have about the numbering of carbon atoms is high. Table 2 also shows a high level of misconception in this regard. Students were asked to differentiate between *ethane*, *ethene*, and *ethyne* in terms of their saturations; most students could not categorize ethane as a saturated compound and ethane and ethyne as unsaturated hydrocarbons. By implication, this is a fundamental issue, as

most students do not understand this concept. This finding resonates with Martin [9], Wang et al. [22], and Sunasee [23], who established that students have various misconceptions about the IUPAC nomenclature of organic compounds.

### **Limitations of the Study**

This study was limited to secondary school; therefore, the generalization cannot be applied across all levels of education. The misconceptions cannot identify all the concepts in organic chemistry; as such, the misconceptions cannot be generalized to all concepts in organic chemistry.

### **Suggestion for Further Study**

Anybody who wants to replicate this study should, therefore, increase the sample size, include more concepts in organic chemistry, and identify teachers' challenges in teaching organic chemistry.

## **4. CONCLUSION**

Diagnosing students' difficulties in this regard has a major impact on students' learning in organic chemistry. Having identified such difficulties would help students to receive targeted support and interventions, which would enable them to overcome those difficulties, build confidence in their ability to name organic compounds, lead to increased motivation and engagement in chemistry, develop a deeper understanding of organic chemistry concepts, and improve their understanding of organic chemistry. Similarly, diagnosing students' difficulties can inform teachers' instruction, enabling them to tailor their pedagogies and materials to meet the specific needs of students; it could also help teachers to identify areas where students need additional support, and this would allow for more effective assessment and feedback. Studies in this regard can also help teachers see the need for additional training or support, promoting ongoing professional development. Diagnosing students' difficulties can inform curriculum development, enabling educators to create more effective and targeted instructional materials. The information obtained from the diagnosis could help educators develop and refine teaching methods that address specific challenges and misconceptions. Diagnosing students' difficulties could offer opportunities for research into teaching and learning, informing evidence-based practices and enabling policymakers to develop targeted initiatives and support systems.

In addition, in order to address and reduce students' misconceptions in this area, various strategies can be adopted in teaching organic chemistry. The teacher can guide the students in discussions, group work, and problem-solving activities; use think-pair-share, peer instruction, or group quizzes to promote active learning. Visual-aid learning can also be used. For instance, virtual labs, molecular modeling software, molecular models, diagrams, and 3D visualizations can be used to display organic structures, reaction mechanisms, bond angles, and hybridization, among others. Multimedia resources, such as videos or animations, can be used to illustrate reaction mechanisms and processes. Teachers can also connect organic concepts to real-world applications, such as applications in pharmaceuticals, medicinal chemistry, materials science, or environmental issues. The teacher can provide students with complex problems or case studies that require the

application of organic chemistry concepts. Providing regular feedback to students on their understanding of organic chemistry concepts would help both the teacher and the students. By incorporating various strategies with technology, educators can create an effective and engaging learning environment for teaching organic chemistry. By understanding the implications of diagnosing students' difficulties in naming organic compounds, educators and policymakers can work together to develop targeted support systems, improve teaching methods, and promote student success in chemistry. An integration of diagnostic tests and assessments into chemistry instruction could reduce students' misconceptions.

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