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UTILIZING CONTEXT-BASED INSTRUCTIONS TO TEACH ALIPHATIC HYDROCARBONS IN ORGANIC CHEMISTRY

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MASTER OF PHILOSOPHY THESIS

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UTILIZING CONTEXT-BASED INSTRUCTIONS TO TEACH HYDROCARBONS IN ORGANIC CHEMISTRY

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Declaration

STUDENT'S DECLARATION

I, CRISPIN KOBINA NYAMEKYE BAIDOO, declare that this thesis, except quotations and references contained in published works which have all been identified and duly acknowledged, is entirely my original work, and it has not been submitted, either in part or whole, for another degree elsewhere.

Signature: ………………………….

Date: ………………………………

SUPERVISORS' DECLARATION

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

Supervisor

Professor Ruby Hanson

Signature: ………………………….

Date: ………………………………

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Dedication

This work is dedicated to my family for their wise words and wisdom shared with me to further my education.

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Abstract

The main purpose of this study was to investigate the misconceptions in aliphatic hydrocarbons in organic chemistry among chemistry students in Winneba Senior High School and to enhance their performance using context-based instruction. The research design employed was a case study which was carried out at Winneba Senior High School in the Central Region of Ghana with a total sample size of 52 students with a mean age of 17 years. The students were purposefully selected, and the research approach used was an action research. The main instruments used to collect data for the study were test (pre-test and post-test), semi-structured interview and observation guide. Both pre-test and post-test contained concept questions designed to identify students' misconceptions and evaluate the effectiveness of the intervention implemented while the interview guide and observation chart, were designed to determine students' awareness and attitude towards organic chemistry. The numerical data of the pre-test and the post-test were analyzed using t-test statistics at an alpha value of 0.05. There was a significant difference between pre-test scores and post-test scores of students (t.cal= 3.33 > t.crit= 2.01). There was no significant difference between the post-test scores of male and female students (t.cal= 0.14 < t.crit=2.02). It was concluded that, context-based instructions had positive impact on students' performance in aliphatic hydrocarbons at Winneba Senior High School. Based on the findings, it was recommended among others that teachers should adopt the use of context-based instructions in teaching organic chemistry to students.

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CHAPTER ONE

INTRODUCTION

1.0 Overview

This chapter highlights the fundamental motivations and essence of the study as well as the peculiar considerations that defined the study. It covers the background to the study, the statement of the problem, the purpose of the study, the research objectives, the research questions, the hypotheses, the significance of the study, limitations, and delimitations to the study.

1.1 Background to the Study

Chemistry instruction's primary objective is to assist students in developing mental representations of chemical phenomena and guarantee that these representations are closely congruent with models that are recognized by science while also challenging and developing their higher-order thinking abilities (Aksela, 2005). When it comes to developing true mental models, organic chemistry is one area of chemistry where students frequently struggle (Hanson, 2017a). Many graduate and professional programmes in human care require an adequate understanding of organic chemistry as a prerequisite. Organic chemistry is essential for the creation of new products for the market and for enhancing many others that we have grown to rely on. It serves as the foundation for the manufacturing of household cleaning products, food flavors, plastics, clothes, automobile tyres, fuel, and cement (Hanson, 2017a). Additionally, the authorities responsible for security and investigations need the chemical knowledge.

Coll (2014) claimed that students view organic chemistry as a significant barrier to pursuing chemistry as a discipline. Numerous elements contribute to students' subpar performance. They include their readiness, the topic knowledge and readiness of the teachers, environmental and social factors (including those at home and school),

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language, and many others (Korau, 2006). Low conceptual foundation, students' disinterest, inept instructors, large class sizes, and psychological fear of chemistry were all specifically mentioned as important explanations for the observed poor performance of learners in Korau's study. Sometimes, negative experiences like subpar grades, apprehension about laboratory mishaps (Hanson & Acquah, 2014), apprehension about participating in practical activities and receiving negative results, a lack of engagement with resources, and teachers' inadequate pedagogical content knowledge can all contribute to loss of interest and attrition (Barr, 2008). One of the three main fields of pure science, together with biology and physics, is chemistry. Various authors have given varying definitions of chemistry. Chemistry, according to Ababio (2004), is the discipline of science that studies the constitution, characteristics, and applications of matter. It enquires into the rules guiding the transformations matter goes through.

Chemistry is a discipline of science that focuses on understanding the characteristics, make-up, and structure of substances as well as the changes that occur when they combine or react under specific circumstances, according to Usselman et al. (2023). Additionally, chemistry can be described and studied in terms of its several areas, including organic, inorganic, physical, analytical, industrial, and nuclear chemistry. Simply said, organic chemistry is the study of carbon compounds, except carbon oxides, metal carbonyls, metallic carbonates, and other related chemicals (Inikori, 2004).

The chemistry of hydrocarbons and their derivatives is known as organic chemistry (Omwirhiren, 2006). Chemical compounds known as organic compounds contain one or more carbon atoms that are covalently connected to atoms of other elements, most frequently hydrogen, oxygen, or nitrogen (Carey, 2023). Humans naturally pick up knowledge from their surroundings by observing with the five senses in both the natural and social realms. From birth to death, everyone is constantly learning, whether they are

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conscious of it or not. In this situation, people, especially students, grow and create a variety of concepts and thoughts about what they learn from their surroundings. As a result, students do not join classrooms as blank vessels, but rather as people who already have some understanding or views about the scientific principles that the teacher would be introducing (Gonen & Kocakaya, 2010). These concepts can be viewed from students' perspectives in a way that is consistent with their strong opinions. These theories and beliefs could be true, however, the majority of them diverge greatly from generally accepted scientific opinions and are frequently arbitrarily reasoned by students by merely taking into account the information provided by their five senses (Omwirhiren & Ubanwa, 2016). They can't adequately describe the scientific phenomena as a result, and their conceptions ultimately depart from accepted scientific theories.

Preconceptions (Barke et al., 2009), alternative conceptions (Pedrosa & Dias, 2000), commonsense reasoning (Talanquer, 2006), misconceptions (Ozmen, 2004), and naive conception (Reiner et al., 2000) are all terms used to describe these discrepancies between the students' viewpoints and the scientifically accepted viewpoints. Some of these false beliefs are simple to dispel, but the majority of students hold these beliefs with deep conviction, making it difficult for conventional classroom instruction to change their minds (Omwirhiren & Ubanwa, 2016). New concepts would be challenging to understand if the misconceptions were not cleared up (Gonen & Kocakaya, 2010).

Some studies have revealed that students pick up their false beliefs about science from a variety of sources (Sani, 2010; Boit et al., 2012). These sources have consistently produced frameworks that are inconsistent or inaccurate representations of scientific concepts. Personal experiences (including observation), sexuality, interaction with peers, media, language, graphical expression, textbooks, laboratory work, environmental, social, and religion are just a few of the sources (Adamu, 2004). Other studies also

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showed that students of various ages shared misconceptions that affected how well they understood more complicated ideas (Lee, 2010). Deshmukh (2009) proposed that language can contribute to or exacerbate misunderstandings because the meanings of identical words in chemistry and everyday speech may differ. Additionally, Oversby (2000) asserted that textbook models simply serve to explain occurrences and have both strengths and weaknesses in terms of preventing misunderstandings. According to Hwang's (2004) research, senior high school teachers are just as confused as their students about what constitutes an acid or a base. Even college students did not comprehend or erroneously believed that adding a solid to a solution has an impact on the equilibrium (Voska & Heikkinen, 2000).

Some important chemistry concepts are becoming less appealing to students. This concept encompasses polymerization, chemical equations, chain reactions, hybridization, and even the nomenclature of organic compounds (Omwirhiren & Ubanwa, 2016).

The biggest barrier to students' learning of chemistry, according to Hanson (2016), is their inability to comprehend the nature of matter and how to connect among its three representational levels. Students frequently struggle to fully comprehend these representations, which result in a flawed and flimsy foundation for further study of chemical processes, particularly in organic chemistry. Mostly, the reasons for students' poor performance are frequently attributed to their poor capacity for retention, lack of enthusiasm, lack of achievement, participation in the wrong social groups at school, and parental problems (Hanson, 2017a). However, other factors, such as the teachers, also have a big impact on the teaching and learning process because they affect how students feel about studying chemistry. Students conduct may have an impact on their performance (Yara, 2009). Students could feel free while accepting responsibility for their actions and learning to create their informed knowledge in more dynamic and

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engaging learning environments where enthusiastic instructors assist and do not interfere with students' constructive efforts (Hanson, 2017a).

Through the provision of health and other social amenities, chemistry raises humanity's standard of living. It is a field in which technological development is dependent. Therefore, any nation's entryway to technological and industrial prosperity must be chemistry education, and organic chemistry education in particular. Context-based instruction (CBI) strategies are the most effective way to accomplish the connections between chemistry and society, as well as between research and practice, may be better understood (Omwirhiren & Ubanwa, 2016). Over the past years, CBI strategies have had an impact on students' interests and learning outcomes in numerous nations (Fechner, 2009; Broman & Parchmann, 2014; Omwirhiren & Ubanwa, 2016; Hanson, 2017a). This is because CBI which inherently necessitates sophisticated thinking and higher-order literacy, mixes chemical content with common situations to make chemistry challenges more authentic and realistic (Hofstein, Eilkis, & Bybee, 2011). As a result, it offers interconnected content knowledge.

According to the context-based instruction principle, people connect ideas and build strong impressions of them based on examples from their daily lives. Context-based instruction, also known as context-based learning (CBL) differs from previous learning theories in that it adopts a constructivist methodology with social foundations. It aims to draw students' attention to science in daily situations so they recognize the connection between science and real-world problems (Bennett et al., 2003).

Context-based instruction is crucial for developing sound conceptions (Archibong, 2009). It also aids in addressing the concern of why one must learn a specific subject or specialty. Here, instruction is delivered in a way that encourages students to relate what they are learning about chemistry to their own experiences and lives (Acar & Yaman,

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2011). Their conceptual attitude, change processes, and ultimately their academic performance would improve if they were aware of how what they learned would affect their lives, the lives of others, and society at large (Bilgin & Yigit, 2017; Udu, 2019). A significant issue is students' poor performance in chemistry at the senior high school level. Many academics believe that this is due to students' misunderstanding a particular component of the subject (Sani, 2010; Mubarak & Yahdi, 2020). The organic component of chemistry is one of them (Johnstone, 2006; Hanson, 2017a). It is understood that for students to learn effectively, they must actively choose, arrange, and create the material meaningfully (Omwirhiren & Ubanwa, 2016). All existing knowledge, including concepts and information processing strategies, play a vital role in shaping learning outcomes because they influence new stimuli and the subsequent generation of meaning. Since learning is a human construct, there is a chance that some constructs would be incorrect and may as a result, negatively affect later learning (Omwirhiren & Ubanwa, 2016). The first step in trying to find a solution for these beliefs would be to identify them. It has been demonstrated that the issue of misunderstanding can be reduced when organic chemistry is taught by using the appropriate strategy or methodology (Bryan, 2007; Keziah, 2011).

A student who only partially comprehends a concept or has a misconception is likely to turn to rote learning. In contrast, a student who fully grasps the concept will approach the issue at hand in his or her own manner and may be able to solve a majority of puzzles correctly. Additionally, there is compelling evidence that students' lack of awareness of common misconceptions in chemistry contributes to their poor academic performance in the subject (Omwirhiren & Ubanwa, 2016).

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1.2 Statement of the Problem

In general, students have performed poorly academically in chemistry (Hanson, 2017a). The West African Examinations Council (WAEC) and educational scholars have studied these dismal performance levels and identified five primary causes. One of them is students' failure to respond to inquiries on organic chemistry in particular logically and conceptually (Hanson, 2017a; Hanson, 2014; WAEC, 2020; WAEC, 2018). Some students do not even try to respond to these queries and most do not understand questions under organic qualitative analysis (WAEC, 2020). Others make poor efforts to solve the problem. Another flaw was identified as the failure to carry out practical tasks, particularly in organic chemistry, which was linked to a shortage of science supplies and other necessary tools, including organic chemicals (Hanson, 2017a).

Knowing that dealing with the frequently volatile and combustible chemical solvents was risky and likely to start a fire, some students reportedly purposefully avoided practical practice (Hanson & Acquah, 2014). There is evidence that activities that have the potential to encourage positive attitudes and give students chances to develop cooperative and communication skills, which enhance higher-order thinking, and context-based instruction is an efficient and effective process for achieving some of the goals for teaching chemistry (Hanson, 2017a). Analyzing the scores of class exercises, assignments, and examinations, it was identified that chemistry students of Winneba Senior High School had this same problem as observed by Hanson and Acquah (2014) and Hanson (2017a) in their separate studies, that students do not respond to organic chemistry questions logically and conceptually.

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1.3 Purpose of the Study

The purpose of the study was to use context-based instructions to enhance the performance of final year chemistry students of Winneba Senior High School in hydrocarbon lessons.

1.4 Objectives of the Study

The objectives of the study were to:

1. Assess the initial conceptions of students in aliphatic hydrocarbons.
2. Assess the attitudes of students towards the use of context-based instructions in teaching aliphatic hydrocarbons.
3. Evaluate students' performance after the use of context-based instructions to teach aliphatic hydrocarbons.
4. Evaluate the effect of context-based instruction on the academic performance of male and female students in aliphatic hydrocarbons.

1.5 Research Questions

The study was guided by the following research questions:

1. What are students' initial conceptions of aliphatic hydrocarbons?
2. What are students' attitudes towards the use of context-based instructions in teaching aliphatic hydrocarbons?
3. What is the effect of context-based instructions on students' performance in aliphatic hydrocarbons?
4. What is the effect of context-based instruction on the academic performance of male and female students in aliphatic hydrocarbons?

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1.6 Null Hypotheses

Ho1. There is no statistically significant difference between students' academic performance in aliphatic hydrocarbon before and after the use of context-based instruction.

Ho2. There is no statistically significant difference between the academic performance of male and female students in aliphatic hydrocarbons.

1.7 Significance of the Study

The outcome of the study will be beneficial in several ways. For instance, it would provide:

1. A catalogue of misconceptions and learning difficulties that students could have in organic chemistry.
2. Empirical evidence to the presentation of chemistry teaching and learning at the senior high level especially in relation to organic chemistry.
3. Authors of textbooks with useful information in their presentation of the subject matter in a form that would facilitate an easier understanding of concepts in chemistry.
4. Information that would be useful in restructuring the curriculum where necessary to correct problems associated with students' misunderstanding of organic chemistry.

1.8 Delimitations

Delimitations emphasize the choices made by the researcher which clarify the boundaries, exceptions, and reservations inherent in the study. Delimitations to the study are also characteristics that limit the scope or define the boundary of the inquiry as determined by the conscious exclusionary and inclusionary decisions, which are made throughout the development of the proposal.

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The study was delimited to final year students of Winneba Senior High School and it addressed problems in teaching and learning of aliphatic hydrocarbons. Also, the research approach for this study prevented the generalization of the research finding.

1.9 Limitations

Limitations to a study are the shortcomings, conditions, or influences that may not be controlled by the researcher which places restrictions on the research methodology and conclusions. Clarifying the limitations of the study allows the reader to understand better under which conditions the results should be interpreted, and also show that the researcher has a holistic understanding of his or her study. Limitations aim to identify potential weaknesses of the study (Baidoo, 2020). Several factors posed limitations to the study. Cardinal among them was noncooperation from students, coupled with student absenteeism. However, this did not have any significant adverse effect on the outcome of the study.

1.10 Definition of Terms

Attitude: Refers to positive or negative feelings or mental state of readiness learned and organized through experience that exerts a specific influence on a person's response to people, objects, and situations.

Learning: A relatively permanent change in behaviour as a result of practice and experience.

Context-Based Instruction (Learning): Refers to the use of real-life and fictitious examples in teaching environments to learn through the actual, practical experience with a subject rather than just its mere theoretical parts.

Concept: Refers to the summary of the important characteristics of a collection of ideas.

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Concept formation: A process by which a person learns to sort specific experiences into general rules or classes.

Concept questions: Also known as higher-order questions are questions that require a learner or respondent to create an answer rather than simply recall.

Hydrocarbon: An organic compound consisting of hydrogen and carbon found in crude oil, natural gas, and coal.

Aliphatic hydrocarbons: These are hydrocarbons typically composed of straight or branched chains of hydrocarbons and are characterized by the absence of a ring or benzene (Carey, 2023).

1.11 Acronyms and their Meanings

CBI:	Context-based Instruction
CBL:	Context-based Learning
TLMs:	Teaching and Learning Materials
WASSCE:	West Africa Senior School Certificate Examinations
SHS:	Senior High School
WAEC:	West African Examination Council
IUPAC:	International Union of Pure and Applied Chemistry
FOS:	Foundation of Science
PBS:	Problem-Based Science
IQ:	Intelligence Quotient

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1.12 Organization of the Study

The research work was organized into five chapters. The first chapter comprises the background to the study, statement of the problem, purpose of the study, objectives of the study, research questions, hypotheses, significance of the study, delimitation, and limitations. Chapter two presents a review of related literature. Chapter three consists of the research methodology, which includes the research approach, research design, population of the study, sample and sampling techniques, research instruments, data collection procedure, and data analysis plan. Chapter four deals with analysis of data and discussion, while chapter five presents the summary of the study, conclusion, and recommendations.

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CHAPTER TWO

LITERATURE REVIEW

2.0 Overview

This section of the study is meant to discuss relevant literature in the area of context-based instructions and how they influence conceptual learning. The review is basically underlined in two main structures, that is the theoretical framework and the conceptual framework. Two main sub-themes, which are the theory of conceptual change and the constructivism theory are discussed under the theoretical framework. To further seek the necessary gap for the study, the conceptual framework entails, the concept of organic chemistry, misconceptions in organic chemistry, concept of context-based instruction and lastly the effect of students' sex on their academic performance. A summary is then provided to highlight the key and salient reviews.

2.1.0 Theoretical Framework Underpinning the Study

A theoretical framework comprises the theories expressed by experts in the field into which one plans to research, which one also draws upon to provide a theoretical coat-hanger for data analysis and interpretation of results. Put differently, a theoretical framework is a structure that summarizes concepts and theories, which you develop from previously tested and published knowledge that you synthesize to help you have a theoretical background or basis for your data analysis and interpretation of the meaning contained in your research data. Swanson (2013, p. 122) explicitly asserted that, "The theoretical framework is the structure that can hold or support a theory of a research study". With respect to this study, the theoretical framework discussed are the theory of conceptual change and constructivist theory.

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2.1.1 Theory of conceptual change

The theory of conceptual change emerges out of Kuhn's (1970) interpretation of changes in scientific understanding through history. Kuhn proposed that progress in scientific understanding is not evolutionary, but rather a series of peaceful interludes punctuated by intellectually violent revolutions, and in those revolutions, one conceptual worldview is replaced by another. That is, progress in scientific understanding is marked more by theory replacement than theory evolution. Kuhn's ideas form the basis of the theory of conceptual change (Posner et al., 1982) which has been used to hypothesize about the teaching and learning of science. The theory of conceptual change has also been used within the context of mathematics education (Caravita & Hallden, 1994; Vosniadou & Verschaffel, 2004; Vosniadou et al., 2006).

Conceptual change starts with an assumption that in some cases students form misconceptions about phenomena based on lived experience, that these misconceptions stand in stark contrast to the accepted scientific theories that explain these phenomena, and that these misconceptions are robust. For example, many children believe that bigger objects fall faster. This is clearly not true. However, a rational explanation as to why this belief is erroneous is unlikely to correct a child's misconceptions. In the theory of conceptual change, however, there is a mechanism by which such theory replacement can be achieved by the mechanism of "cognitive conflict". Cognitive conflict works on the principle that before a new theory can be adopted, the current theory, which could be deficient, needs to be rejected. Cognitive conflict is meant to create the impetus to reject the current theory. So, in the aforementioned example, a simple experiment to show that objects of different sizes actually fall at different speed will likely be enough to prompt a child to reject their own personal, initial or current understanding. The theory of conceptual change is not a theory of assimilation. It does not account for those instances

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where new ideas are annexed onto old ones. Nor is it a theory of accommodation, in that it does not account for examples of learning through the integration of ideas. The theory of conceptual change is highly situated, and applicable only in those instances where misconceptions are formed through lived experiences and in the absence of formal instruction. In such instances, the theory of conceptual change explains the phenomenon of theory rejection followed by theory of replacement.

This last argument is based on more than the use of synonyms, although given the fact that the terms beliefs and conceptions are often used interchangeably in literature, such an argument could be a valid one. The theory of conceptual change, as the explanatory framework described above, is applicable only in those instances where misconceptions are formed through lived experiences and in the absence of formal instruction, there is a phenomenon of concept rejection, and there is a phenomenon of concept replacement. Liljedahl et al. (2007) demonstrated that each of these criteria applied equally to some cases of pre-service teachers rejecting and replacing their views about mathematics or the teaching and learning of mathematics.

In such instances, relevant lived experience can be drawn from their time as students. As learners of mathematics, they have both experienced the learning of mathematics and the teaching of mathematics, and these experiences have impacted their beliefs about the teaching and learning of mathematics (Chapman, 2002). These experiences can be viewed as having happened outside of a context of formal instruction because, although they are situated within the formal instructional setting of a classroom, the object of focus of that instruction is on content rather than theories of learning, methodologies of teaching, and philosophical ideas about the nature of content.

In either case, the relevant lived experience plays an important role in the construction of conceptions, or beliefs, and the teaching and learning that impacts on their practice. When

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these conceptions are rejected and the new conceptions are adopted then a conceptual change occurs. In social interactionism, individuals are considered not passive objects but interactive and intentional subjects who interact with the environment based on combined thought and behaviours (Bigge & Shermis, 2004). They try to give meaning to their environment and behave not as an automatic device but as thoughtful and purposeful beings. The goal of cognitive learning is to develop student academic and thinking skills from a novice level to a more expert level and to provide adequate experiences in which students structure the learning and teaching themselves (Watson & Konicek, 1990). One of the important factors in cognitive teaching is to foster student motivation to become active learners through interactions with the environment. The primary method that incorporates cognitive ideas into teaching is the employment of information processing, which refers to how information is learned, modified, or changed (Kambouri, 2015). Its emphasis is on perceptual and conceptual processes that allow the learner to perceive and determine functions of recognition, memory, and problem-solving. This procedure is quite similar to a computational system that processes information from concrete to abstract, simple to complex events, and to provide learners with multiple examples to reinforce the organized information (Taylor & MacKenney, 2008). Learning finally occurs as a result of the learner's adaptability to internal functions that create new experiences.

2.1.2.0 Constructivism theory

According to Dewey (2006), education depends on action. Knowledge and ideas emanate from situations in which learners have to draw on experiences that have meaning and importance to them. Constructivism, a variant of cognitivism, is based on the belief that an individual constructs his or her understanding of the world in which he or she lives by reflecting on personal experiences (Brown & Green, 2006). Learners are not supposed to

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wait for knowledge to be filled but play an active role in seeking meaning and nurturing self-awareness. When encountering a principle, concept, or phenomenon that does not make sense, learners often interpret or generate new rules to comprehend ideas. They can develop different interpretations of similar things based on their living environments and interactions with others. In other words, human understanding is contextually embedded and interpersonally influenced by the living environment.

Constructivist ideas hold that learning occurs when people actively participate in the learning process and combine new knowledge with prior knowledge (Bigge & Shermis, 2004; Margunayasa et al., 2019). Learning is considered an active process of constructing rather than receiving knowledge. Teaching is also seen as a process that helps students build ideas rather than imparting knowledge. When implementing constructive strategies, teachers may begin with the knowledge that students already possess and guide them toward new knowledge by asking probing questions and utilizing scaffolding tools (Oliva, 2009). Scaffolding refers to a spiral instructional model that provides extensive support and a framework of sequential lesson contents to gradually build up students' understanding of new concepts based on their prior knowledge (Gagne et al., 2005).

In constructivism, social communities have a strong impact on constructed meaning, thus initiating the term social constructivism (Bigge & Shermis, 2004; Bada, 2015). Social constructivism emphasizes the important role of social and cultural contexts that help transform and share meaning among groups of people. Said another way, without social interactions and interdependent relationships, learners cannot construct understanding (Ogunleye & Bamidele, 2013). This principle encourages a teaching approach that should emphasize social interaction in the sense that it can engage learners in learning tasks and optimize learning outcomes (Wlodkowski, 2008). Among the learning models germane to constructivist theories are cooperative learning and context-based learning help build

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up learners' understanding of disciplinary areas through team collaboration, everyday communication, and the application of academic knowledge to real-life situations.

The theory of constructivism has many elements (Kurt, 2021). The following outline the theory as a whole and how they affect the learning of the students. The main points are:

- Knowledge is constructed: Every student begins the learning journey with some preexisting knowledge and then continues to build their understanding on top of that. They will select which pieces of the experience to add, making everyone's knowledge unique.
- Learning is a social activity: Interacting with others is vital to constructing knowledge. Group work, discussions, conversations, and interactions are all important to creating understanding. When we reflect on our past experiences, we can see how our relationship with others is directly connected to the information learned.
- Learning is an active process: Students must actively engage in discussions and activities to construct knowledge. Students can't take on a passive role and retain information. To build meaningful ideas, there must be a sensory response.
- Learning is contextual: Isolation is not the best way to retain information. We learn by forging connections between what we believe and the information we have already. Learning also occurs in the situation within the context of our lives, or alongside the rest of our understanding. We reflect on our lives and classify the new information as it fits into our current perspective.
- People learn to learn, as they learn: As each student moves through the learning journey, they get better at selecting and organizing information. They can better classify ideas and create more meaningful systems of thought. They also begin to recognize that they are learning multiple ideas simultaneously, for example, if

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they are writing an essay on historical events, they are also learning elements of written grammar. If they are learning about important dates, they are also learning how to chronologically organize important information.

- Learning exists in the mind: Hands-on activities and physical experience are not enough to retain knowledge. Active engagement and reflection are critical to the learning journey. To develop a thorough understanding, students must experience activities mentally as well.
- Knowledge is personal: Because every person's perspective is unique, so will be the knowledge gained. Every individual comes into the learning activity with their own experiences and will take away different things as well. The theory of constructivist learning is based entirely on each individual's perspective and experiences.
- Motivation is key to learning: Similar to active participation, motivation is key to making connections and creating understanding. Students cannot learn if they are unwilling to reflect on preexisting knowledge and activate their thought processes. Educators must work to motivate their students to engage in the learning journey.

Constructivism is a theory of knowledge (epistemology) and a theory of learning. It is not any particular pedagogy. Constructivists believe that human beings are active information receivers. They use their existing experience to construct an understanding that makes sense to them (Omwu & Randall, 2006). Humans assimilate and accommodate new knowledge and build their own understanding. Since knowledge is viewed as personal and subjective and reality resides in the mind of each person, learning takes place when individuals make use of their existing knowledge and experience. Thus, multiple interpretations of an event are possible, and multiple answers to a question are

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the source of creativity in learners. It is held by constructivists that learners need time to reflect on their experiences in relation to what they already know. After some time, they reach a consensus about what specific experience means to them. Some proponent constructivists will now be presented and their ideas considered in activities that will follow. Some constructivists to be considered would be Jean Piaget, Lev Vygostsky, and Ernst Von Glasersfeld

2.1.2.1 Jean Piaget

Piaget's constructivist theory is based on analogies with biological evolution and adaptation (Bada, 2015). He believed that the child's own actions in this world were important for cognitive development. This means that knowledge is built by students based on prior knowledge (Bada, 2015). The social context was important in this development process. Cognitive structures build up from simple initial processes in conjunction with personal action and experience. The development is a form of adaptation to the environment.

2.1.2.2 Lev Vygotsky

Vygotsky believed that the developmental process was governed by the learning process. Pedagogy creates learning processes that lead to development. He distinguished between actual (development) and potential (learning) levels of development. The actual level is achieved independently, while potential levels are obtained by the guidance of an adult. According to Vygotsky (1978) (cited in Bada, 2015), in the process of constructing knowledge, the learner is not only active internally but also engaged in a social context with the learning material. Here comes the use of cognitive conflict. If the designed activities lead students to a framework that differs from correct scientific concepts, it creates cognitive conflict. This conflict should be neither too easy nor too difficult. That is, the conflict should neither be beyond their capabilities nor should be too easy. It should

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be within Vygotsky's zone of proximal development. When a child cannot accomplish a task alone and can find a peer who possesses a slightly higher cognitive level, one within the child's zone of proximal development, the child can complete the task with that person's assistance. In Piagetian cognitive constructivism, the emphasis is on the individual constructing knowledge through a cognitive process of analyzing and interpreting. In Vygotskian social constructivism, the emphasis is on the social interactions with the teacher and peers.

2.1.2.3 Ernst Von Glasersfeld

Von Glasersfeld is known for his radical constructivist philosophy. According to Von Glasersfeld, knowledge is not passively received but built up by the cognizing subject. He calls his theory a theory of knowing rather than a theory of knowledge (Bada, 2015). Von Glasersfeld underscores the importance of active learning. Knowledge is entirely constructed out of social relations. Knowledge needs to be relevant and related to the person's interest. The teacher can create environments so that kids can act upon the basis of their ideas and discover which of their ideas lead to friction and need revision.

Von Glasersfeld, agreed with Piaget that humans develop concepts and understanding of the world over time (Slezak, 2010). Instead of adhering to the traditional philosophical view that knowledge is a component of truth, that is, that it corresponds to objective reality, knowledge is classified according to its applicability in the field of experience (Walshe, 2020). This suggests that all knowledge is created, rather than sensed. This is called the radical constructivism theory.

Constructivist scientific education emphasizes learning through experience and calls for active engagement with the subject matter. Even while students actively participate in the construction of knowledge, their prior knowledge may impede their efforts to develop an understanding of concepts toward the recognized scientific position. In general, figuring

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out students' preconceptions before instruction could serve as a bridge to more amicably connect what they already know with the expected one. Diagnostic assessments are utilized for such educational reasons in order to clarify students own concepts of science. (Bayrak, 2013). Therefore, diagnostic tests assist teachers of physics and chemistry in understanding the concepts that students have.

2.2.0 Conceptual Framework

A conceptual framework is the total, logical orientation and associations of anything and everything that form the underlying thinking, structures, plans practices, and implementation of an entire research project. A conceptual framework comprises one's thoughts on the identification of a research topic, the problem to be investigated, the questions to be asked, the literature to be reviewed, the theories to be applied, the methodology to be used, the methods, procedures and instruments, the data analysis and interpretation of findings, recommendations, and conclusions to be made (Ravitch & Riggan, 2017). I adopted Ravitch and Riggan's definition of conceptual framework as "an argument about why the topic one wishes to study matters, and why the means proposed to study it are appropriate and rigorous" (p. 5). For example, a conceptual framework for a study on learning styles would present the reason why studying the particular aspect of learning style is important, with that reason rooted in the literature; for whom studying the particular aspect of learning style might make a difference; and how the planned design and methods of the study are appropriate and rigorous. In view of the above definition of a conceptual framework, the review under this theory seeks to discuss, the concept of organic chemistry, the misconception in organic chemistry, context-based learning/instruction, and lastly to discuss the effect of sex on student performance.

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2.2.1 The concept of organic chemistry

Organic chemistry is the subdivision of chemistry that treaties with the structure, properties, and reactions of combinations that contain carbon, and these compounds are known as hydrocarbons since they contain both hydrogen and carbon atoms mainly. A review by Hanson (2017a) found that in Ghana, the teaching of organic chemistry is taken seriously and so all secondary school children learn some amount of it as well as its many benefits to mankind.

Organic chemistry is the study of the structure, properties, reactions of molecules containing carbon (Sibomana et al., 2021) and the preparation of carbon-containing compounds, except oxides of carbon (CO_2 and CO), carbonates (CO_3^{2-}), hydrogen carbonate (HCO_3^{-}), carbides (C^{4-}), and cyanides (CN^{-}) (Inikori, 2004). In simple terms, organic chemistry is the chemistry of hydrocarbons and their derivatives (Omwirhiren & Ubanwa, 2016). Due to its tetravalent nature, propensity for catenation, ability to form isomers, long chains, branching chains, and ring structures, ability to create both single and multiple carbon-carbon bonds, and ability to mix with other elements, carbon can be found in a wide variety of compounds (Chang & Goldsby, 2016; Petrucci et al., 2017). Within this diverse number of compounds, similarities in the type of structure and chemical reactions. By structure, carbon compounds can be classified as aliphatic, alicyclic, aromatic, and heterocyclic (Ameyibor & Wiredu, 2006).

In terms of chemical reactions, organic compounds are classified based on the presence of functional groups (Chang & Goldsby, 2016). Ameyibor and Wiredu (2006) reported that when a carbon-containing molecule is written as R-OH, then all R-OH are similar, they are alcohols. Though R-NH_2 are also similar, they are different from the alcohols due to the -NH_2 functional group and so they are called amines. The -OH and -NH_2 are called functional groups, giving an organic molecule its distinctive chemical features are

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an atom or a group of bound atoms (Ameyibor & Wiredu, 2006; Chang & Goldsby, 2016). The simplest organic compounds are the hydrocarbons (Petrucci et al., 2017). Hydrocarbons are classified as saturated (alkanes), unsaturated (alkenes and alkynes), and aromatic hydrocarbons (benzene rings or similar features) (Ebbing & Gammon, 2017). By changing the carbon-carbon bond or adding additional atoms, it is possible to create different organic compounds from the hydrocarbon, including alkanols, alkanoic acids, alkyl alkenoates, amines, and amides (Ameyibor & Wiredu, 2006). These are derivatives of hydrocarbons (Ebbing & Gammon, 2017). The fact that each family of organic compounds shares the same basic molecular formula and the functional group is noteworthy.

2.2.2.0 Misconceptions in organic chemistry

Concepts are ideas, notions, or thoughts which can be regarded as the emerging image of the mental process (Lakpini, 2006). It may be a product of some intuitive re-appraisal; the only problem is that a concept could be concrete, abstract, or even blurred. Adamu (2004) defined concepts as a summary of the essential characteristics of a group of ideas.

Misconception might also be referred to as preconceived notions, non-scientific beliefs, naïve theories, mixed conceptions or conceptual misunderstandings. Works of literature have explained that misconceptions are differences between the scientifically accepted views and students' views (Aufschnaiter & Rogge, 2010); alternative conceptions (Adu-Gyamfi et al., 2020); commonsense reasoning (Ozmen, 2004); preconceptions (Kambouri, 2015); non-scientific beliefs (Impey et al., 2012); pre-instructional beliefs (Treagust et al., 2004) and many others. Whatever the language, the main idea is that students' prior knowledge or perceptions of the natural world, which they bring to class with them, might affect how well they understand their formal science experiences in the classroom, influencing how they acquire new concepts (Cakir, 2008; Kartal et al., 2011).

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Basically, in science, there are instances where the ideas in the mind of individuals may be different from what is scientifically correct (Sani, 2010). What is of great concern about misconceptions is that individuals continue to build knowledge on their current understanding which could have negative impact on future learning. The study of misconceptions has generated considerable interest among science educators such as it is essential for a successful teaching and learning interplay.

Various authorities have different views on what misconception is, for instance, Watson and Konicek (1990) (cited in Sani, 2010), described misconceptions as personal constructions, which are formed on what an individual feels or sees. These experiences have profound effect on the learner's willingness and ability to accept other more scientifically grounded explanations of how the world works. They opined also that misconceptions are erroneous beliefs or alternative views of scientific principles or wrong notions about certain scientific concepts. Chiu (2005) agreed that students do not understand fundamental ideas covered in classroom teaching instructions. Even some of the best students give the right answers but only using correctly memorized words. When questioned more closely, these students reveal their failure to understand fully the underlying concepts (Ealy & Hermanson, 2006).

Many studies have shown that students develop their scientific misconceptions from many sources (Desimone et al., 2002; Dikmenli & Cardak, 2008; Soyibo, 2008; Sani, 2010; Donkoh, 2017). Those sources have always created inconsistent frameworks or incorrect representation of the scientific concepts. The sources include but not limited to personal experiences (such as observation), gender, peer interaction, media, language, symbolic representation, textbooks, laboratory works, environmental, social, religion among others (Adamu, 2004; Ayicheh, 2020).

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Without organic chemistry, household things like soaps, plastics, radios, televisions, books, and computers would not be available (Ebbing & Gammon, 2017). As a result of the relevance of organic chemistry, in Ghana, it is taught to all SHS students as a core in integrated science and as an aspect of elective chemistry (Hanson, 2017a). Its understanding will be required for the study of any science or technology-related subjects, including medicine, pharmacy, engineering, agriculture, physics, geology, and ecology (Chang & Goldsby, 2016). Simply put, organic chemistry education and learning will increase sustainable development and better our lives.

Although the value of chemistry cannot be disputed, researchers and chemical educators have frequently noted that organic chemistry is challenging (Ellis, 1994; Engida, 2014; Chang & Goldsby, 2016). There are various aspects of organic chemistry that have been studied, like how to depict organic molecules (Johnstone, 2006; Hanson, 2017b), naming and writing structural formulae of organic compounds using the IUPAC nomenclature system, isomerism, properties of organic compounds, and aromatic compounds as difficult areas for students (Adu-Gyamfi & Asaki, 2022).

Consequently, teaching and learning organic chemistry has become a great concern to educationists and researchers (Abreh, 2018). Numerous studies have been conducted to pinpoint the challenges involved in chemistry teaching and learning in order to provide solutions that might lead to improved performance (Carvalho-Knighton & Keen-Rocha, 2007; Omwirhiren & Ubanwa, 2016; Uce & Ceyhan, 2019). Student-related factors, like their background issues, lack of interest, or negative attitude toward chemistry, and teacher-related factors, like inadequate teacher preparation and teaching strategies, qualified chemistry teachers, and inadequate instructional materials, are the things that prevent students from succeeding in organic chemistry (Barbour & Reeves, 2009; Baidoo, 2020). O'Dwyer and Childs' (2017) investigation of the factors affecting students'

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struggles with organic chemistry is more thorough. O'Dwyer and Childs (2017) reported from summaries of several related pieces of literature that students' struggles with learning organic chemistry are a combination of extrinsic and intrinsic factors, including cognitive ability, attitudes toward learning, and misconceptions. Examples of extrinsic factors include the multidimensional nature of chemistry, its complex language, its relationship with mathematics, laboratory work, and chemical curricula.

Other experts in the field of chemical education discovered that the subject and its ideas are to blame for the challenges in helping pupils understand organic chemistry (Johnstone, 2010). For instance, studying chemistry is usually difficult due to three factors: a lack of algorithms, a demand for three-dimensional images, and a large amount of new jargon (Johnstone, 2010). These difficulties emanate because the subject and its concepts have a distinct vocabulary (Chang & Goldsby, 2016). Organic chemistry topics are complex, students must think across three domains when studying chemistry (Johnstone, 2010). The macroscopic domain is comprised of what is tangible and visible, such as a beaker of ethanol or ethanoic acid, the sub-microscopic domain is comprised of what is molecular and invisible, such as ethanol or ethanoic acid atoms and bonds, while the symbolic domain is comprised of all other domains (that is, chemical formulas, equations, diagrams, for example, CH_3COOH and C_2H_5OH displaying ethanoic or ethanol atoms and molecules). To put it simply, studying organic chemistry involves a significant cognitive strain. A combination of these dimensions or even just one of the dimensions would be difficult for a learner with little or no prior knowledge of organic chemistry to comprehend (O'Dwyer & Childs, 2017). The difficult task of connecting the microscopic and macrocosmic worlds would fall to the teachers. Thus, motivating students to learn would be a teacher's enormous duty (Quadros et al., 2011).

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Notwithstanding the aforementioned challenges associated with the subject, teachers have a role to play in addressing them (Stojanoyska et al., 2020), because teachers are seen as catalysts of the expected changes (Nbina, 2012). According to Okorie and Akubuilo (2013), teachers are the classroom managers; they control what happens in the classroom and direct students based on their understanding of the curriculum's philosophy, objectives, and material as well as the recommended pedagogical strategy for implementing it. Consequently, the effectiveness of teaching organic chemistry in schools cannot surpass the effectiveness of chemistry teachers. There is, therefore, little question in anyone's mind that educators may have a significant impact on students' interest in and performance in the sciences (Anim-Eduful & Adu-Gyamfi, 2021). Identifying teachers' specific problems in implementing curriculum effectively, particularly in organic chemistry, can help address students' weak performance and ensure effective curriculum implementation.

Also, several researchers also revealed that students at different ages held similar misconceptions that influence their understanding of more complex concepts (Lee, 2004; Gonen & Kocakaya, 2010). Deshmukh (2009) posited that language can cause or increase misconception because the meanings of the same word in chemistry are different from the language used in daily life. Oversby (2000) argued that models used in textbooks only provide explanations of phenomena, and they have their strengths and limitations to misconception.

Hwang (2004) found that not only students of secondary schools have misconceptions in identifying whether a substance is an acid or a base, but their teachers had misconception as well. Voska and Heikkinen (2000) in their study noted that even college students did not understand or misconceive how adding a solid to the solution influences the equilibrium state. Students' aversion to certain key concepts in chemistry is on the

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increase. Such concepts include hybridization, chain reaction, chemical equation, polymerization and even nomenclature of organic compounds (Sani, 2010).

Johnstone (2010) reported that despite the numerous research done over the last 40 years, many of the problems identified in the 1970s are still there. Johnstone (2010) noted that despite the fact that we have generated tools for teaching and learning, suggested teaching methods, and thorough explanations of learning psychology, our students continue to leave us in a state of disappointment and disillusionment that we had wanted to avoid. Hence, teachers' difficulties in teaching cannot be ignored. According to Mudau (2013), to positively influence meaningful learning of science, it is crucial to identify and address teaching difficulties that hinder meaningful learning.

Addressing misconceptions requires effective teaching strategies that emphasize conceptual understanding, real-life applications, and the relevance of organic chemistry in diverse fields. Providing hands-on laboratory experiences, interactive discussions, and engaging visual aids can help dispel these misconceptions and foster a deeper understanding of organic chemistry among students (Ardac & Akaygun, 2004; Burrows & Mooring, 2015; Hanson, 2017a).

2.2.2.1. Misconceptions among students

Students generally have misconceptions that all branches of chemistry are difficult especially, organic chemistry (Hanson, 2017b). In a finding by Hanson (2014; 2016) it was established that the inability of Ghanaian students to understand the nature of matter and connect among the three representational levels of matter (macroscopic, microscopic, and representational) are the main factors that impede their study of chemistry. Study by Hanson (2017b), emphasised that most students are unable to understand these representations well and thus form a faulty and weak foundation for further study of chemical concepts, especially in organic chemistry. Adu-Gyamfi et al. (2013) also carried

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out studies on students' conceptions and performance in the International Union of Pure and Applied Chemistry (IUPAC) nomenclature of organic compounds and found that Ghanaian high school students had weak performance in naming and writing structural formulae of alkenes, alkynes, alkanols, alkanoic acids, and alkyl alkanoates. Further studies by (Adu-Gyamfi et al., 2017) showed that students' difficulties in IUPAC naming of organic compounds included their inability to identify the correct number of carbon atoms in the parent chain and to identify a substituent or functional group. To remediate these difficulties, Hanson (2016; 2017b) suggested that teachers could simplify abstract chemical concepts by using concrete examples and everyday life questions. This approach would help students form mental models, focusing on the scientific aspect through individual, small-group, and whole-class discussions.

However, the West African Examinations Council (WAEC), the principal organization in charge of Ghana's senior high school (SHS) examinations, continually reports the poor performance of students in organic chemistry despite the efforts of teachers to enhance the performance of students. A paper by the WAEC chief examiner's reports on chemistry (WAEC, 2017; 2018) noted that students struggle with organic chemistry, including recalling terms like catalytic cracking, functional groups, aliphatic compounds, aromatic compounds, and drawing structures of organic compounds. There is the possibility that students may still struggle to understand organic chemistry.

Misconceptions among students regarding organic chemistry can arise due to a variety of reasons. Some common misconceptions include:

1. Organic chemistry is memorization-based: Students often have the misconception that organic chemistry is solely about memorizing reactions, molecules, and formulas. However, organic chemistry is a discipline that requires understanding

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and application of concepts through logical reasoning and problem-solving skills (Khan, 2015).

2. Organic chemistry is too abstract: Students may find it challenging to visualize and understand the abstract concepts and three-dimensional structures in organic chemistry, leading to misconceptions about the subject being overly complex or irrelevant (Sani, 2010).

3. Organic chemistry is unrelated to real-life applications: Some students struggle to see the practical relevance of organic chemistry in everyday life, leading to the misconception that the subject is purely theoretical. However, organic chemistry plays a critical role in pharmaceuticals, materials science, agriculture, and other industries (West, 2014).

4. All organic compounds are harmful or toxic: Students may have a misconception that all organic compounds are dangerous or harmful to health. While some organic compounds can be toxic, not all organic compounds are harmful, and many naturally occurring compounds are essential for life (Hanson & Acquah, 2014; West, 2014).

5. Organic chemistry is only for pre-medical or chemistry majors: Some students may believe that organic chemistry is only necessary for those pursuing careers in medicine or chemistry. However, organic chemistry concepts are applicable in various fields, including pharmacy, agriculture, environmental sciences, and biochemistry (Hans, 2017; Hanson, 2017a).

To further add to the above discussion on student misconceptions in organic chemistry, it is critical that educators are aware of the cognitive level and ability of their learners, if not, the multiple-level cognitive demands of chemistry, along with the other scientific

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and quantitative requirements of the course, will overwhelm the students (O'Dwyer & Childs, 2017). This is owing to the fact that due to their disparities in experiences and cognitive ability, what may be simple for the instructor to understand may not be simple for the student to understand. Since students may enter the classroom with prior knowledge that are non-scientific beliefs, teachers must learn to understand students' attitudes, preconceptions, and perceptions to tailor instruction for meaningful learning, as these factors significantly influence students' performance in a subject (Cetingul & Geban, 2011).

2.2.2.2 Misconceptions among teachers

As discussed earlier not only do students have difficulties or misconceptions about the study of chemistry; rather teachers may also have some ideal misconceptions in teaching chemistry. A study by Chen and Wei (2015), revealed that aspiring science teachers had misunderstandings about a number of concepts, including geometric and structural isomerism, the Markovnikov Rule and its antithesis, the nomenclature of cycloalkenes, the polymerization reaction, and the synthesis of alkenes from alcohols and alkyl halides. Some of these beliefs were found to be present in his research for the first time, while others were found to be similar to those in his literature. One of the primary causes of the misconceptions is past knowledge of potential science teachers. Similar results were also seen in earlier research (McDermott, 1984; Driver, 1989). For instance, some aspiring science educators felt that a compound could not exhibit geometric isomerism if all of the groups linked to the C=C bound differ from one another. Additionally, while demonstrating geometric isomerism, chemistry instructors frequently utilize particular examples like 1,2- dichloroethene. Students may therefore think that geometric isomerism can only be found in compounds that have two halogen atoms bound to double-bonded carbon atoms (Baidoo, 2020).

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In the case of Ghana, Nartey and Hanson (2021) emphasized in their study that teaching and learning is a difficult process with many endogenous and exogenous factors influencing classroom experiences and relationships. The teachers' perspectives, and how the material is presented, have a considerable impact on the learners' experiences and development of understanding.

In Nartey and Hanson's (2021) study, the preparation and chemical reactions of alkynes, the structure and stability of benzene, benzene reactions, the comparison of benzene and alkene reactions, and polymers, and polymerization were all found to be difficult to teach by a sizable number of teachers. The majority of students, however, found the following organic chemistry topics to be challenging: naming of alkanes, structural isomerism, and petroleum; preparation and chemical reactions of alkenes and alkynes; structure and stability of benzene; reactions of benzene; comparison of benzene and alkene reactions; and polymers and polymerization. Both teachers and students saw the structure and stability of benzene, benzene reactions, reactions of alkenes and alkynes, and polymers and polymerization as difficult topics in organic chemistry (Nartey and Hanson, 2021).

Students felt the same way about all of the topics that teachers thought were challenging to teach. O'Dwyer and Childs (2017) explained that while teachers' positive attitudes and interest in organic chemistry can enhance learners' experiences, their perspectives and perceptions significantly influence their learners' perspectives and learning of various topics. The insights gained about teachers' and students' perceived difficult organic chemistry topics in this study imply that teachers' perceptions and how these are communicated with the students can have significant effects on learning. It is therefore important that teachers are aware of their influence on their learners in generating preconceptions about difficult topics. The success of the teaching and learning of these topics may be influenced by instructors' judgments of the difficulty of the topics, which

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may then affect their students' experiences and perceptions even though teachers are obliged to relate with students by reassuring them (O'Dwyer & Childs, 2017).

The findings of Adu-Gyamfi and Asaki (2022), entail that teachers' misconceptions include preconceived ideas, factual mistakes, and conceptual omissions but not non-scientific views or vernacular misconceptions. Consequently, this study has categorized the misconceptions teachers have in organic chemistry into preconceived notions, factual misconceptions, and conceptual misunderstandings. Hence, in order to deal with factual misconceptions and conceptual misunderstandings with few preconceived notions, chemistry educators should adopt instructional approaches that will help pre-service teachers challenge and deal with their misconceptions in organic chemistry (Araujo & Santos, 2018). In addition, the teachers' partial understanding of misconceptions is partly due to some factual difficulties.

2.2.3.0 Concept of context-based instruction

From the literature on organic chemistry, the teaching and learning of organic chemistry is difficult (Sana & Adhikary, 2017). The difficulties stem from the fact that it is abstract (Hanson, 2017a). Teachers will need to employ several representations in order to explain this abstract concept (Olaleya, 2012). Using context-based instruction is one effective way to teach abstract concepts, such as organic chemistry (Hanson, 2017a) as well as other areas of science (Bilgin et al., 2017). The Latin language describes the word context as "*contexere*", which stands for; weave together, coherence, connection, and relationship (Gilbert, 2006). With this said, the effect of the word context seems of a great influence. With the use of a context during a chemistry lesson, a chemistry topic and various concepts can be connected to contemporary scientific matters. Learning through a context can contribute to a coherent structural meaning of new content that clarifies chemistry concepts (Acar & Yaman, 2011; Soltura, 2021). Mostly the current chemistry curricula

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are not yet designed to transfer knowledge via a contemporary context such as; scientific articles or research but more in a traditional way via a study book (Vos et al., 2010; Baidoo, 2020). Gilbert et al. (2011) pointed out that there are five major challenges that should be considered by designing a context-based curriculum; a clear purpose, an overload of content, no coherence in learning by students, relevance seems unclear to students and the shortcoming of transferring knowledge to new and other contexts.

Context-based instruction (CBI) provides an alternative to the more traditional lecture approach to teaching (Hanson, 2017a). CBI or CBL, previously called problem-based learning but changed due to the negative connotations of the word 'problem' and the importance of utilizing context when teaching health care is a learning concept that originated in Canada in the 1960s at McMasters University and was used initially to prepare medical students for practice (Dochy et al., 2003; Alexander et al., 2005). The process of CBI involves students being provided with a scenario, and undertaking a student-led process of hypothesizing, which ultimately results in the development of the student's own learning needs. As a teaching tool, CBI utilizes a group approach to learning the process of working together, creating discourse and leads students towards a solution focus.

CBI as an inductive method of teaching and learning includes trial and error in the classroom, and group discussion is seen as a powerful enhancer of learning (Prince & Felder, 2007; Fernandes et al., 2013). The role of educators who use CBI is to facilitate learning (Hanson, 2017a) and to assist students in being creative, critical thinkers in an open environment. According to Alexander et al. (2005), the main barrier to implementing CBI is the educator's hesitance to change practice from a content-driven process to a student-led process. The nature of CBI facilitation is probably the most difficult aspect to grasp as there is a change of roles from educator to facilitator.

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Wu (2003) studied students, who worked in small groups, at a small high school. Students in Wu's study were taught science in the context of local topics and real issues with practical applications during a three-year integrated science program, called Foundations of Science (FOS). An example of a FOS topic that the students in Wu's research worked on was determining if their water was safe to drink. Wu (2003) observed that in this type of learning environment, real-life situations made the concepts students learned meaningful. Observations made during classroom discussions between students and teachers led Wu to believe that through FOS, students were able to see that science is not a special kind of truth (Wu, 2003), and that an experience such as this allows students to see how classroom science lessons relate to and can be linked to their lives.

Bouillion and Gomez (2001) studied two self-contained classes of 5th grade students in Chicago as they worked on a real-world problem in the community called the Chicago River project. This project was chosen by the students and involved the cleanup of a local riverbank that was polluted. The students wrote letters to local businesses and surveyed members of the community. Bouillion and Gomez focused on how varied types of scientific concepts can be used to advance student learning, with an emphasis on learning in urban areas. They explained that the project allowed the school and community to come together to promote learning. In their study, data was collected through observations, field notes, student artifacts, and pre-instruction and post-instruction interviews with teachers and students. Student responses to questions, posed by teachers, demonstrated an understanding of scientific concepts such as systems and cycles. The researchers also found evidence, through the students' conversations and activities, that the students demonstrated that they had learned concepts such as water quality, and soil erosion. The teachers in the study reported that the students also improved their ability to

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access information, form questions, share ideas, and analyze and compare data (Bouillion & Gomez, 2001).

Aybuke and Omer (2012) stated that for meaningful learning to occur, new knowledge must be related by the learner to relevant existing concepts in that learner's cognitive structure. That is, according to them, the most important single factor influencing learning is what the learner already knows. In this respect, traditionally designed methods are not so effective in developing conceptual understanding of the subject matter (Aybuke & Omer, 2012).

Schneider and Krajcik (2002) studied Problem-Based Science (PBS) through the FOS program at a small alternative high school. Students in the program studied broad driving questions, worked on projects that lasted several weeks and integrated the sciences: earth, biology, chemistry, and ecology. Schneider and Krajcik (2002) wanted to determine if students involved in PBS would score as well as students nationally on achievement test items.

To convey concepts, educational messages, and the skills required by the learners, it is essential to create opportunities that enable learning through practical and actual experiences, not just theoretical endeavour (Hassanpour et al., 2015). Context-based instruction in teaching underlines the application of knowledge in realistic scenarios, enhancing the understanding of the subject matter (Fensham, 2009; Baidoo, 2020). It is an educational approach that employs problem-solving-based learning, in which real and clinical experiences are used in the educational environment. The method incorporates several real-life situations as the basis of learning allowing the learner to analyze the situation and to search for concepts accordingly, which enables the students to develop critical thinking skills (Yilmaz et al., 2022).

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According to Hanson (2017a) and Baidoo (2020), the implementation of CBI is effective in improving students' attitudes toward professional behaviour and critical thinking. Research by Hanson (2017a) has demonstrated improvement in students' understanding and interest in organic chemistry when lessons are taught using CBI.

2.2.3.1 Competencies of implementation of context-based instruction

There is general agreement that school teachers have a significant impact on how any innovative educational strategy is implemented. The successful implementation of context-based instruction requires educators to possess certain competencies. To address the idea of CBI in the science classroom, in particular, De Putter-Smits et al. (2013) recommended that teachers possess the competencies needed to establish a context-based learning environment. The competencies comprise "context-handling, regulating students' learning, adequate emphasis, and re-designing of science materials" (De Putter-Smits et al., 2013, p. 3). Therefore, it is expected that teachers who possess the following competencies will be most successful in implementing context-based instructions in the classroom.

- Context-handling: As stated by De Putter-Smits et al. (2013, p. 11), "context handling refers to the teacher competence in handling contexts, establishing concepts and making the concepts transferable to other contexts". The instructor must be able to effectively convey to the students the context of the science curriculum material in this component. Even though teachers could come across content in environments they are not familiar with, teachers must be able to get familiar with any context presented in the science curriculum material, according to De Putter-Smits et al. (2013), and present and explain it to the students. The competency of context-handling also includes the choice of which context to use, how to use this context, which concepts are appropriate in the context, and how

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to make concepts transferable to other contexts (Gilbert, 2006). Concerning the selection of contexts, studies have highlighted the involvement of learners in the selection of interesting and relevant contexts for effective context-based instruction (Basu & Barton, 2007; Bellocchi et al., 2016; Savelsbergh et al., 2016). If this option is ignored, students may have difficulties in circumstances that don't match their needs, expectations, preferences for time, surroundings, and other factors (Pilot & Bulte, 2006; De Jong, 2008; Pilot, 2012).

- Regulating student learning: Teachers must be skilled in regulating the learning process so that learners are given the ability and learning environment to create their meaning of learning materials by using a context-based approach (Zimmerman & Schunk, 2011). The instructor must possess the necessary skills to manage and direct the classroom environment following context-based scientific education regulations so that students can actively participate in the teaching-learning process (De Putter-Smits et al., 2013). In the context-based science teaching and learning approach, teachers should be skilled at encouraging students' sense of ownership and responsibility both on the subject matter as well as on their learning (Gilbert, 2006; Parchmann et al., 2006; Kind, 2009).

- Teachers' teaching emphasis: Scientific knowledge needs to be applied to address significant concerns that people confront in their daily lives, not merely to supply answers about theoretical sciences, which is the focus of context-based instruction. De Putter-Smits et al. (2013) developed two elements of context-based scientific teaching to assess teachers' ability to teach effectively. These include uncertainty and investigation. The provision of opportunities for students to experience scientific knowledge as dynamic, non-foundational, and influenced by culture and society as well as by theory-dependent inquiry is referred to as

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uncertainty. Uncertainty, in essence, has to do with how much students perceive scientific knowledge as provisional or tentative. The investigation relates to how much attention is placed on skills, inquiry, and their application to inquiries and problem-solving both within and outside of the classroom.

- Re-designing science curriculum and instruction: Another factor that could affect the practice of the context-based teaching approach is the level of teachers' competency in re-designing the existing teaching materials. Of course, the success of context-based instruction depends on the quality of the curriculum materials, and their effective implementation inside and outside the classroom (Prins et al., 2018). However, teachers' interpretations and adaptations are vital in determining how educational innovation is performed in the classroom, and it has long been known that they do not always implement an innovative curriculum exactly as it was intended (Van Den Akker, 2004). Besides, science curricular resources aren't always sufficient for every classroom or every student's particular learning needs. As a result, teachers need to adapt the teaching materials to suit the environment of their classroom and the resources available at their school (De Putter-Smits et al., 2013). Tzou and Bell (2010) stated that teachers need to adapt the science teaching materials to link to students' interests and experiences to enhance students' perceptions of the relevance of science to their everyday lives. De Jong (2008) attempted to clarify the use of contexts for science teaching and learning by identifying four domains as the origin of contexts. These are personal, social, societal, professional practice, and scientific and technological domains. By considering these domains, teachers can re-design the science curriculum during their classroom teaching. The need for re-designing teaching materials is more expected in context-based education than in conventional education, and it

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necessitates more effort on the part of the teacher. Teachers, therefore, need to have some competencies in adjusting the materials for classroom instruction.

By developing and refining theses competencies, educators can create engaging and meaningful learning experiences for their students, enhancing students understanding and application of knowledge within real-world context. As education continues to evolve, it is crucial for educators to adapt their instructional practices and keep up with the competencies needed to effectively implement context-based instruction. Only through continuous growth and development can educators ensure that their students are prepared for success in the real world.

2.2.4.0 Effect of students' sex on their academic performance

Gender, according to Anderson (2004) refers to the social attributes and opportunities associated with being male or female and the relationship between women and men and girls and boys as well as the relations between women and those between men. These attributes, opportunities, and relationships are socially constructed and are learned through socialization processes. They are context or time-specific and changeable. Gender determines what is expected, allowed, and valued in a woman or a man in a given context. In most societies, there are differences and inequalities between women and men regarding responsibilities assigned, activities undertaken, access to and control over resources, as well as decision-making opportunities. Gender is part of a broader socio-cultural context.

Gender implies the different roles, rights, and responsibilities of men and women and the relation between them. Gender does not simply refer to women or men, but the way their qualities, behaviours, and identities are determined through the process of socialization. Gender is generally associated with unequal power and access to choices and resources (Alimi et al., 2012). The different positions of women and men are influenced by

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historical, social, religious, economic, and cultural realities. These relations and responsibilities can and do change over time. The use of the term gender also recognizes the intersection of women's experience of discrimination and violation of human rights not only on the basis of their genders but also from other power relations that result from race, ethnicity, caste, class, age, ability, disability, religion and a multiplicity of other factors. Women and men are defined in different ways in different societies, the relation they share constitute what is known as gender relation. However, there is no known society where men and women have equal power relations. Gender relations constitute and are constructed by a range of institutions such as family, legal system, or the market. Gender relations are hierarchical relations of power between women and men and always tend to be disadvantageous (Greiff & Neubert, 2014).

Most studies show that, on average, girls do better in school than boys (DiPrete & Buchmann, 2013; Stout et al., 2016; Aguinis et al., 2018). Girls get higher grades and complete high school at a higher rate compared to boys (Finn, 2008; DiPrete & Buchmann, 2013; Aguinis et al., 2018). Standardized achievement tests also show that females are better at spelling and perform better on tests of literacy, writing, and general knowledge (National Centre for Education, as cited in Finn, 2008). An international aptitude test administered to fourth grades in 35 countries, showed that females outscored males on reading, and literacy in every country. However, there was no difference between boys and girls on science tests in fourth grade (Finn, 2008). Girls continue to exhibit higher verbal ability throughout high school, but they begin to lose ground to boys after fourth grade on tests of both mathematics and science ability. The gender differences in science and mathematics achievement have implications for girls' future careers and have been a source of concern for educators everywhere.

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Gender disparities in education and most importantly, in academic achievement is never a new occurrence but had existed for a long time. Evidence of research in this area is numerous, showing that girls are not performing as adequately as their male counterparts in universities (Becker, 2005; Finn, 2008; Erickson, 2009). Aiken (2007) noted that males are highly ranked compared to females in academic achievements. The existence of a gender gap in some American schools was also confirmed by Glenn (2009) who attested that there is a wide gap between the genders in school performances. He observed from an analysis of negligible diversity which indicates that there is only moderate variation in the gender gap across schools suggesting that almost all girls had the ability to reach high achievement levels. On the other hand, Fryer and Levitt (2009) reported that the gender gap in students' results is very consistent across demographic groups and hence their basic conclusion was that there is a variation in the gender gap across schools. Kelly (2007) stated that boys are ahead of girls in the sciences with the largest difference being in mathematics and practical test.

Gordon (1995) discovered that boys are portrayed by teachers as being more serious-minded with academic work, quick cognitive capacity, and the ability to handle difficult and demanding school responsibilities. However, Finn (2008) in a study observed that educational performances of girls and boys in Britain followed a constant pattern showing evenness of achievement of success at all levels. In the school setting boys seem to dominate interactions and discussion or question-and-answer sessions, whereas girls meet the expectation for their gender when they are quiet or display harmonizing characters. Besides, Vock et al. (2011) noted that students' achievement relies majorly on their intellectual capacities.

Issues of gender and students' academic achievements have remained controversial for a long time. In the USA, researchers have argued that males performed better than females

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in academics, while others have argued that the reverse was the case. For example, Calsmith (2007) explained that the influence of gender and differences in academic achievement was a complex task, thus many studies appeared to be contradictory. Feldman (2010) conducted a study on the effect of gender differences on academic achievement in Early Childhood kindergarten classes. This was attributed to the fact that there was an assumption that male children were more intelligent than female students. Feldman’s study established that children of both sexes start school with roughly similar potential to learn. Their scores on IQ tests were approximately equivalent when gender difference was controlled. The study, however, found out that girls’ advantage in reading became apparent by third grade and gender differences continued to increase through eighth grade. The study, furthermore, established that the test scores of female students decrease over time when children move up the ladder in the education arena. From Feldman's (2010) study, it was evident that there are environmental factors that contributed to the decreased intelligence quotient of female students in their education. According to Brandriet et al. (2011), females have less interest in learning chemistry because of their emotional attitude and intellectual accessibility. Hence, the males perform better than the females in chemistry class (Chan & Bauer, 2015).

Some studies indicate that boys achieve better (Gipps 2004; Daluba, 2013; Omwirhiren & Anderson, 2016), either no difference between boys and girls (Udousoro, 2003; Ventura, 2008; Muhammed, 2014; Ajayi, 2016) or girls outperform boys (Soyibo, 2008; Lawal, 2009; Calsambis 2013) have been demonstrated. Studies on gender differences in chemistry achievement continue to yield inconsistent results and it has usually been attributed to unequal exposure of males and females to learning instructions relevant to chemistry learning. Treatment interaction according to Abonyi (2014) generally implies that different learners with different characteristics may profit more from one type of

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instructional method than from another and that therefore may be possible to find the best match of learners' characteristics and instructional method in other to maximize learning outcomes.

Over the past decade, researchers (Eccles & Harold, 1991; Xiang et al., 2003) have conducted studies on gender differences in expectancy-related beliefs. Generally, male students were identified to hold higher ability beliefs and expectancies for success in most traditional accounting education than female students (Jacobs et al., 2002; Xiang et al. 2003). Furthermore, empirical evidence proved that gender differences among students are a result of perceived gender appropriateness of the activities performed. (Lee et al., 1999; Solomon et al., 2003). That is, when students engage in works deemed as gender appropriate, their expectancy-related beliefs tend to grow. Xiang et al. (2003) examined but found no gender differences in expectancy-related beliefs among fourth graders (primary four) in a running programme. Gender differences are also observed in subjective task values. Many researchers (Eccles & Harold, 1991; Fredricks & Eccles, 2002; Jacobs et al., 2002) who have examined gender differences have shown that, compared with females, males like arithmetic more hence they place higher importance on attending science class (Eccles & Harold, 1991; Wigfield & Eccles, 1992; Lee et al., 1999).

2.2.4.1 Factors that cause gender differences in academic performance of students

Factors contributing to the gender academic performance differences are many and complex and have been classified into various groups such as biological, innate, out-of-school, and inside-school factors. Traditionally, males' academic performance was considered superior to that of females especially in male-dominated subjects like mathematics and sciences because of higher levels of innate spatial ability (Benbow & Stanley, 1983; Omwirhiren & Anderson, 2016). At the same time, females' performance

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was placed above their male counterparts in language because of their greater verbal and reasoning abilities (Wilberg & Lynn, 1999).

Takyi, et al (2021) also noticed that there is a disparity in Ghana's educational system regarding gender, and as the level of education increases gender parity worsens in Ghana. Among other things, these explanations include:

- Biological determinism: According to this hypothesis, biological causes account for gender disparities in science and technology. It is biologically inherited. This suggests that while spatial aptitude is sex-linked in favor of men, verbal expression is sex-linked in favor of women. It is biologically inherited. Aguinis et al. (2018) disputed this claim and shows that empirical evidence has disproved the biological theory that males are innately more intelligent than females.
- School type: These variable contrasts single-sex and coeducational schools. It is said that the type of school female students attended has a direct impact on their interest in and performance in science-related subjects. When it comes to science, it was once thought that girls in single-sex schools had an advantage over those in coeducational schools. The praise given to single-sex schools for educating females, according to Seeker (as cited in Eze, 2008), has less to do with the fact that they are single-sex schools than it does with their ability to expose women to superior learning environments. According to Nkpa (as cited in Eze, 2008), single-sex schools have a challenge with persuading girls to enroll and perform well.
- Teacher impact: The gender of the science teacher, the standards of the teacher, and the way the scientific teacher interacts with students in the classroom are all examples of how the teacher has an influence (Takyi et al., 2021). The majority of the world's science teachers are men, which gives science a masculine aspect,

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> including Ghana and other west African countries. Observation shows that in the majority of Ghana's regions, culture plays a key part in this mismatch. Women had to go to school before they could decide whether or not to study science, they used to be looked down upon for their knowledge. Nonetheless, as more girls enroll in school, there are an increasing number of female science teachers (Takyi et al., 2021).

Based on the analyses presented, teachers' methods would have differing effects on male and female students. Effective teaching methods promote contact between the teacher and the class, but some of these methods may result in learning settings that are not equally supportive of both sexes. Students' participation is essential to learning, and active learners may retain more information. This study sought to find a realistic method that gave boys and girls an equal chance to understand chemical bonding.

Nevertheless, the current thinking is that gender difference in academic performance is not solely attributed to innate differences in males and females. But there are other numerous factors influencing educational ability, including, but not limited to economic, cultural, social, and differences in educational systems and techniques (Gallagher, 2001). The above discussions explained that sex affects the performance of an individual but not uniquely.

2.3 Summary

Reviewed literature indicates that chemistry education is important in national development. Hence, the need for every student at Winneba Senior High School to learn some selected topics in chemistry which includes organic chemistry as found in Ghana SHS syllabus. Organic chemistry is one of the aspects of chemistry where students have misconceptions.

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For better understanding of concepts, there is the need for teachers to employ the use of context-based instructions which connects with real life situations as lived in and outside the school setting. Context-based instruction makes lessons more interesting and meaningful; it develops social living or awareness in students and so it frees teachers from being termed as "talking teacher".

It is of great interest to note that when organic chemistry lessons are taught with the right teaching and learning materials using context-based instruction, there may be no statistically significant differences in the academic performance of male and female students

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CHAPTER THREE

METHODOLOGY

3.0 Overview

This chapter presents the methodology employed in carrying out the study. These include the research approach, research design, population of the study, sample and sampling techniques, data collection instrument, data collection procedure, data analysis plan, and ethical considerations.

3.1 Research Approach

The research approach adopted for the study was action research. Action research is usually conducted to solve an educational problem in a local setting. According to Mills (2011), action research is a systematic investigation done by teacher-researchers, counsellors, administrators, and other individuals with a stake in the teaching and learning process or environment to learn more about how their particular school runs, how they teach, and how well their students learn. Information is gathered with the goal of addressing and improving the challenges or otherwise that they face in their school communities. Teachers use action research to gather useful information to improve the way that their educational setting, teaching, and students' learning happens (Mills, 2011). According to Creswell (2012), action research is comparable to mixed methods research in that it addresses a specific, practical issue and looks for solutions to a problem by using either quantitative or qualitative methods or both in the process of data collection. Buttressing the foregoing, Cohen et al., (2018) asserted that, action research is a powerful and impressive tool for improving quality at the local level. In this case, assisting final year students of Winneba Senior High School to improve their performance in aliphatic hydrocarbons in organic chemistry was the focus of the study.

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3.2 Research Design

Research design refers to the researcher's strategy for obtaining the required data to address the objectives of the study. It is effectively, the plan for what a study will involve, and how it will be conducted. Every research study is unique in its own way, especially with how it is undertaken. According to Bryman (2008), research design provides a framework for the collection and analysis of data. Hence, designing a study helps researchers plan and implement the study in a way that will help them obtain the intended results, thus increasing the chances of obtaining information that could be associated with the real situation. In principle, the decision to use any method to collect and analyze data is influenced by the research design. The design used for this study was a case study. Creswell and Plano-Clark (2011) define a case study as an analysis of a bounded system or a case over time through data collecting involving numerous sources of information rich in context. A case study is both the process of learning about the case and the product of our learning (Stake, 2003). According to Stake (2003), the case to be studied could be a specific issue, object, person or group of people, a school, an educational system, etc. An effective way to determine whether a theory or model genuinely accounts for occurrences in the real world is to do a case study (Hanson, 2017a).

3.3 Population of the Study

According to Wimmer and Dominick (2006), the population of a study defines the boundaries of the body of content to be considered and is determined by the topic area and the period of time. It is the entire collection of items from which samples can be taken for a study. The study population consisted of 234 final year science students of Winneba Senior High School, from which a sample was taken.

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3.4 Sample and Sampling Technique

A sample, according to Schwartz (2009), is a group of individuals who participate in a study, while sampling is a method of studying from a few selected items, instead of the entire big number of units. The particular method used in the sampling process is termed as sampling technique (Schwartz, 2009). The sample size for the study was 52, which was made up of 23 females and 29 males. They were selected through purposive sampling. The justification for the choice of this sampling technique was that the researcher taught that class and therefore had sufficient knowledge of the performances of the students, which was not encouraging.

3.5 Data Collection Instruments

According to Polit and Hungler (1999), data collection is the process of obtaining information (data) in the course of a study or investigation. They further indicated that within each general research approach, one or many data collection procedures or techniques may be used. Some of these data collection methods include available information, observation, interviews, questionnaire administration, and focus group discussions (Polit & Hungler, 1999). For this current study, the instruments used to gather data were semi-structured interview guide, test (pre-test and post-test), and observation chart. Semi-structured interview is the most widely used method in qualitative research because it allows a thorough examination of experiences, feelings, or opinions (Dunne et al., 2005), and was chosen for this study. A semi-structured interview was selected because it allowed the interviewer to focus on the research objectives, yet opened up new avenues for further questions (Ary et al., 2014).

The semi-structured interview was done with an interview guide (Appendix C) in which those questions in the guide were posed to thirty (30) students who were selected using simple random sampling from the intact class. According to Mills (2011), gathering

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qualitative data will often have smaller sample sizes compared to quantitative ones because of saturation. Saturation occurs when, after a certain number of responses to the same set of questions, no new data are identified.

The semi-structured interview guide was developed in accordance with the research objectives. The interview guide hinged on 10 items and observation chart helped to answer the research questions one and two. Test scores from both pre-test and post-test were analyze to answer research questions three and four.

A pre-test (Appendix A) was used at the diagnostic stage to establish the existence of the problem. At the post-intervention stage, a post-test (Appendix B) was used to evaluate the effectiveness of the interventions implemented. Both the pre-test and post-test were made up of conceptual questions. Semi-structured interview (Appendix C) allowed a wide range of participants' understanding to be explored and also revealed important aspects of the phenomenon under study. An observation chart (Appendix G) was also used at the interventional stages to assess students' participation in the lesson taught. Marking scheme were prepared for the pre-test (Appendix D) and post-test (Appendix E) and scores were awarded accordingly (Appendix F).

3.6 Validity and Reliability of the Instruments

All measurements, especially measurements of behaviours, opinions, and constructs are subject to fluctuations (errors) that can affect the measurements' reliability and validity. Validity refers to the extent to which an instrument used to elicit information from respondents is able to give the response needed from respondents. Reliability on the other hand deals with the extent to which an instrument when administered to the same people under similar conditions will show consistency in its character (Baidoo, 2020). To ensure the validity of the tests, the items were given to the research supervisor to

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examine and help correct any problem pertaining to validity, be it content, construct, or face validity. The test items were also constructed to match the outcome being measured. Poorly constructed items were substituted with more appropriate ones after the examination of the items by the research supervisor. The test items were based on the research questions to ensure the content validity of the instrument.

Reliability on the other hand refers to the consistency or stability of measurement results. Reliability determines whether or not a measure can be confirmed by further measurement. To ensure the reliability of the test items, both pre-test and post-test were re-administered to the same class seven days after their administration. This means the researcher practiced test-retest reliability. The students were also made aware that the test would be centered on aliphatic hydrocarbons only. They were also made aware of the structure of the test even before the day they sat for the paper. In addition, standard administrative rules governing the conduct of the test were clearly stated. Finally, it was also ensured that the questions captured in both tests were at the same level of difficulty, and structure. Data from the test were statistically analyzed to determine the reliability of the test instruments using Pearson Product Moment Correlation Coefficient. The analysis yielded reliability coefficients of 0.72 and 0.81 for the pre-test and post-test instruments respectively.

According to Ary at al. (2002), if the measurement results are to be used for making a decision about a group or for research purposes, or if an erroneous initial decision can be easily corrected, then the scores with modest reliability coefficient above 0.50 may be acceptable. Also, according to Madan and Kensinger (2017), reliability coefficients above 0.70 are acceptable, and above 0.80 are of high reliability. Therefore, the reliability coefficients for the pretest and post-test signifies that both test instruments are considerably reliable.

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3.7.0 Trustworthiness of Data

Trustworthiness of a study refers to the degree of confidence in data, interpretation, and methods used to ensure the quality of a study (Robson & McCartan, 2016). Additionally, it can be said that trustworthiness in research is attained when a researcher clearly shows and establishes the protocols and procedures involved in carrying out a study so that the study can be considered worthy of consideration by readers (Stahl & King, 2020).

There are four criteria that research must meet in order to be considered as trustworthy (Lincoln & Guba, 1985 in Stahl & King, 2020). These include the following:

3.7.1 Credibility

Credibility essentially refers to the confidence that can be placed in the truth of research findings. It establishes whether the research findings represent plausible information drawn from the participants' original data. As qualitative research explores people's perceptions, experiences, feelings, and beliefs, it is believed that the participants are the best judge of whether or not the research findings have been able to reflect their opinions and feelings accurately.

The establishment of credibility of findings demands that the research is carried out according to good practice and by submitting it to the social world that was studied for confirmation that the researcher understood that social order correctly. Prolonged engagement of participants is a technique to ensure credible interpretation of findings (Stahl & King, 2020). To achieve credibility, the researcher spent four months in the field engaging with participants.

3.7.2 Transferability

Transferability entails the generalization of a study's results and it can be achieved through the description of the research context and underlying assumptions which can

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make the research results transferable from the original research situation to a similar situation (Stahl & King, 2020). The researcher achieved this in the study by extensively and thoroughly describing the process that was adopted for others to follow and replicate. Thus, the researcher kept all relevant information and documents regarding the study. Also, in this study, the research context, and methodological processes were provided. These could enable other researchers to apply the findings of this study to similar settings of their choice thereby regarding the findings in this study as answers in their chosen contexts. Furthermore, the researcher kept an accurate record of all activities while carrying out the study. These included the raw data (transcripts of interviews) as well as details of the data analysis.

3.7.3 Dependability

Dependability requires that when replicating experiments, the same results should be achieved (Stahl & King, 2020). To achieve dependability, the researcher must ensure that both the process and the product of the research are consistent. Dependability was established through the establishment of appropriate enquiry decisions. This included a review of interviewer bias to resist early closure and at the same time prevent the provision of unreliable data due to boredom on the part of the participants because of prolonged interview sessions. In addition, information from the literature assisted the researcher in developing questions that elicited appropriate responses to answer the research questions formulated to guide the study. There was a systematic data collection procedure that reached the point of saturation, the extensive documentation of the data (transcriptions of interview narratives) and methods of analysis are steps in proving the dependability of the data. The thesis supervisor assessed the work to find out whether or not the findings, interpretations, and conclusions were supported by the data.

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3.7.4 Confirmability

Confirmability refers to the degree to which research results could be confirmed or corroborated by others (Stahl & King, 2020). In order to establish confirmability, the researcher after transcribing the audiotapes and coding, and treating all other relevant information and documents regarding the study, gave the results back to the participants to confirm the responses. The researcher effected changes where necessary and gave the transcribed data back to the participants again for them to authenticate the inferences derived by the researcher. The researcher then took the final transcribed data from the participants as a true record of what they factually provided.

3.8 Pre-intervention

To establish the existence of the problem, the researcher used question and answer technique and a pre-test to access the initial concepts that students have in aliphatic hydrocarbons. The performance of students in the pre-test were scored (Please, see Appendix E) using a prepared marking scheme (Appendix D).

3.9.0 Implementation of Intervention Lessons

To enhance students' performance in organic chemistry, the researcher-facilitator designed interventional lessons to that effect. The intervention lessons lasted for six weeks and below is how the implementation was done.

Week 1 (Intervention lesson 1)

Topic: Introduction to Aliphatic Hydrocarbons and Alkanes

Activities

The lesson was introduced by organizing students to watch a short video on the classification of aliphatic hydrocarbons. Students were asked about the importance and uses of aliphatic hydrocarbons and common examples in their surroundings. Saturated hydrocarbons (alkanes), also known as paraffin was introduced and their structures were

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discussed with the help of molecular models. Rules in naming saturated hydrocarbons were spelt out to students using the idea of first name as organic substituents, middle name as inorganic substituents and surname as the parent's name of alkane compounds, after which they engaged in extensive practice that required application of the rules for naming hydrocarbons.

In groups (8 groups), students gave out names of saturated hydrocarbons for other groups to come out with the right structures with the help of the molecular model and vice versa. In the same intact groups, students discussed chain isomerism and were asked to give isomers of alkanes from a given molecular formula. This led to the discussion of the physical properties of alkanes such as boiling points, volatility, and solubility. From the knowledge that water cannot be used in washing off ink or oil paints, solubility of alkane as well explained to students.

Since boiling points of aliphatic alkanes depend on the number of carbons and surface area, papers were shaped into different sizes and lit to make understanding easier. It was observed that papers with small surface area burnt faster compared to papers with large surface area. The lesson was summarized by asking students questions on key information and knowledge as well as taking home exercises to work on.

Week 2 (Intervention lesson 2)

Topic: Alkanes

Activities

Week two began with a short question and answer exercise that assessed students' previous knowledge. Students were asked to explain why a painter does not use water but turpentine or kerosene to wash off oil paint from his or her brush after painting. The laboratory preparation of alkanes was discussed. It included; hydrogenation, Wurtz reaction, reduction of alkyl halide, decarboxylation of alkali metal salts of carboxylic

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acids, reduction of alkyl halides (Grignard reagent), and reduction of carbonyl compounds. Types of organic reactions such as substitution reaction, addition reaction, elimination, and rearrangement reaction were discussed and students had a chance to watch videos on these reactions.

Many examples and exercises on reactions were given to students in groups to try and later discussed by the whole class. Just as it is impossible to dissolve cooking oil in water, alkanes are virtually insoluble in water but soluble in organic solvents such as kerosene. The uses of alkanes were discussed and their importance to human life were also discussed. Each group came out with a summary of what they had learnt and a group assignment was given.

Week 3 (Intervention lesson 3)

Topic: Alkenes

Activities

The lesson was introduced by discussing unsaturated hydrocarbons and the functional group of alkenes. Sources of alkenes, the structure of alkenes, rules in naming alkenes, and their physical properties were discussed. Molecular models and papers were used to explain physical properties such as boiling points. Isomerism in alkenes such as structural isomerism was discussed with the help of molecular models. Also, with videos and molecular models, the types of geometric isomers (cis-isomer and trans-isomer) as well as the effect of geometric isomerism on the physical properties of alkenes were discussed. The lesson came to an end with the researcher-facilitator summarizing the key points. Assignments were given to students to be discussed the following week.

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Week 4 (Intervention lesson 4)

Topic: Alkenes

Activities

The lesson was introduced by discussing the assignments given the previous week. Students were asked to explain the reason why liquefied petroleum gas and kerosene are used as cooking or heating fuel. Laboratory preparation of alkenes such as dehydration of alkanols, alkenes from vicinal dihaloalkanes, alkenes from dehalogenation, alkenes from the hydrogenation of alkynes, alkenes from cracking of petroleum was discussed and with the help of videos.

Chemical reactions of alkenes were discussed as well, and that made room for the discussion of Markownikoff's rule as well as Anti-Markownikoff's rule. The mechanism for this reaction was well explained with the help of molecular models and videos. The uses of alkenes and their importance to human life were discussed. The researcher-facilitator summarized the lesson and group assignment was given based on chemical reactions of alkenes and the uses of ethene.

Week 5 (Intervention lesson 5)

Topic: Alkynes

Activities

The researcher-facilitator introduced the lesson by discussing some relevant previous knowledge, the functional group of alkynes, the structure of alkynes, and the nomenclature of alkynes were discussed. Isomerism in alkynes was discussed and that led to the discussion of the physical properties of alkynes. At this point, the physical properties of alkynes such as melting point and boiling point were discussed.

With the help of videos, the various methods for the preparation of alkynes were discussed and molecular models were used to explain some of the mechanisms involved

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in the reactions. The uses of alkynes were discussed and assignments were given out to students.

Week 6 (Intervention lesson 6)

Topic: Summary of Aliphatic Hydrocarbons

Activities

The first day of this week saw the groups of students having a quiz competition on aliphatic hydrocarbons which had been taught for the past five weeks. Various ways of testing for alkanes, alkenes, and alkynes were discussed and some practical activities were carried out. The idea that it is difficult to break a bunch of brooms was used to explain the bond strength between alkanes, alkenes, and alkynes. Many exercises and assignments, as well as a test (post-test), were given to students.

3.9.1 Problems encountered

The following factors hindered the pace of the study.

- Inadequate support from other instructors during laboratory practical sessions as they see the process as time-wasting and cumbersome.
- Inadequate instructional aids in the school for the teaching and learning process.
- Less spacious classroom environment.
- Regular absenteeism of most students due to poor health conditions.
- Long distances from their residence to the school.

3.10 Post- intervention Phase

After the intervention, a post-test was conducted to find out how the intervention activities helped the students to improve their performance in the concept. The post-test was not the same as the pre-test, with the reason that if the intervention has been effective then the students should be able to answer simple questions on hydrocarbons. The post-test consisted of six (6) items and the duration of the test was forty (40) minutes

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(Appendix B). Answers provided by the students in answering the post-test questions were marked using a marking scheme (Appendix D).

3.11 Data Analysis Techniques

The qualitative data collected was thematically analyzed using qualitative approaches. Information gathered from participants in the interview was transcribed verbatim from audio to text format. The data were then analyzed according to themes and content as this was to ensure a deeper understanding of the issues under consideration. More so, direct quotes from the participants were integrated with the discussion. This was meant to give voice to the work as this expressed their intent, emotions, and viewpoints.

Data analysis was made in accordance with the procedures described by Bell (2010). These procedures involve a number of steps that are outlined below:

Listening many times to the recorded tape in order to develop familiarity with the data. "Initial noting" of potential themes was done in the margins; hence, each theme was coded (for example, using an abbreviation). Themes or titles were recorded as headings on a blank sheet of paper and verbatim examples from the text were written under each of the headings. From time to time, information that was considered to be in support of the identified themes was noted and positioned under the appropriate title headings. New themes that emerged from later transcripts were tested against earlier transcripts and any congruent information from earlier transcripts was recorded at the right-hand margin under the appropriate theme title.

After each transcript had been read and coded, the coded segments were recorded under the appropriate theme headings. Each theme was then examined using the coding to define the theme more clearly. Comparisons were made across the themes and this allowed for the identification of super-ordinate themes, which appear to link originally disparate material. When those themes were identified, they were checked against

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original transcripts to find out whether the themes made sense in terms of the integrity of the single participant.

In summary, the researcher-facilitator went through the following processes in analysing the data in themes:

1. Data familiarisation: At this stage, the researcher-facilitator organised data from field notes and audio recordings of interviews from participants into transcripts and reread the transcripts several times.
2. Code formation: After the transcription of the data, the researcher organised the data by coming up with codes that imaged the transcripts.
3. Identifying theme: The researcher then transformed the codes into specific themes or categories.
4. Refining the themes: At this stage, the researcher-facilitator sorted out the themes, and checked for repetitions, similarities, and differences that emerged so as to refine the data.
5. Defining and naming themes: During this stage, the researcher finally refined and defined the themes for analysis.

Using t-test, frequency, percentage, and rating scale, the data were analyzed. Both paired and unpaired sample t-tests were conducted to test hypotheses one and two respectively at 0.05 level of significance.

3.12.0 Ethical Considerations

In accordance with the ethics of research, the researcher first and foremost sought permission from the school authorities with a letter from the Department of Chemistry, University of Education, Winneba before carrying out the study (Appendix H). The researcher briefed the participants in advance about the purpose of the study and sought their consent to indicate their willingness to participate in the interview. Regarding the

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issue of confidentiality, the names of participants were not written and their contributions remained anonymous. Privacy was observed during fieldwork and no unauthorized persons were allowed to access data collected. Participants were informed that their information would be treated confidentially and that they reserved the right to withdraw from the study even during the process if they so wished.

3.12.1 Voluntary participation and informed consent

Participants were provided with accurate and adequate information on the goal and procedures of the research to fully understand and in turn decide whether to participate or not (Punch, 2009). This makes informed consent a prerequisite to any research in which human beings are involved as participants. For instance, in this study, the researcher clearly spelt out the purpose, nature, and significance of the study to the participants. No participant was forced to participate in the study.

3.12.2 No harm to participants

The idea of informed consent, according to Babbie (2012), codifies the ethical standards of participants' assent and no harm to them. As a result, participants' voluntary involvement in research studies is based on their thorough comprehension of any associated risks. Physical harm or emotional harm can both occur (Strydom & Venter, 2002). Physical harm or emotional harm can both occur (Strydom & Venter 2002). Babbie (2012) also stated that the researcher should be cautious of undetectable risks. A conscious attempt was made by the researcher to prevent any responder from suffering bodily, psychological, or emotional harm while the study was being conducted. Participants were cordially welcomed, the interview was private, and the questions were politely asked without the use of unpleasant language.

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3.12.3 Anonymity

The interests and well-being of research subjects must be safeguarded. The study should therefore make every effort to conceal or blind the identities of participants (Aso-Oliyah, as cited in Trochim & Donnelly 2006). Readers of the study shouldn't be able to link a particular response to a specific participant (Babbie, 2012). In this study, the names of the participants were never made public; instead, numerical codes were used. Additionally, the written report and the recorded responses omitted information about the participants' real names. Additionally, the written report and the recorded responses omitted information about the participants' real names.

3.12.4 Confidentiality

Information handling in a confidential manner is referred to as confidentiality (Strydom & Venter, 2002). This implies that the researcher should carefully protect the information provided by the participants so that only the researcher has access to it. The interview was conducted in a private, non-interruptive setting where the subjects felt more at ease and relaxed during the interview. Prior to taping the interview, the researcher obtained consent from the participants.

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CHAPTER FOUR

RESULTS AND DISCUSSION

4.0. Overview

This chapter presents the statistical analysis of the research data, findings, and discussions of the research data. The analysis was conducted based on the research questions posed.

4.1.0 Results and discussion

The purpose of the study was to use context-based instructions to enhance the performance of final year chemistry students in hydrocarbons, a sub-unit of organic chemistry. The results obtained from students' interviews, classroom observations and test scores are presented and analyzed in this section. The results are presented in the order of the research questions propounded in chapter one.

4.1.1 Thematic analysis

The thematic analysis brought to light the multifaceted nature of attitudes towards aliphatic hydrocarbons, misconceptions within this domain and varying perspectives on context-based instructions, including students' interest toward the use of context-based instructions in teaching aliphatic hydrocarbons.

Interest towards hydrocarbons: Students showed little interest in learning aliphatic hydrocarbons before the intervention. Majority of students gave several reasons why they showed little interest which included; the abstract concepts, lack of relevance, overemphasis on memorization, teaching approach and insufficient visual aids. After the intervention, many participants expressed a clear interest in aliphatic hydrocarbons, acknowledging their crucial role in fueling numerous industries and supporting global energy demand. Some participants mentioned their fascination with the complex

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chemical structures of aliphatic hydrocarbons, noting the diversity of compounds within this category. They enjoyed learning about the different types of aliphatic hydrocarbons and their uses. This interest was often tied to a curiosity about the extraction, refinement, and utilization of hydrocarbons, with students recognizing the significance of these processes in society.

Misconceptions in aliphatic hydrocarbons: Students also highlighted various misconceptions surrounding aliphatic hydrocarbons, particularly in relation to their environmental impact. Some students expressed a belief that all aliphatic hydrocarbons are inherently harmful to the environment, overlooking distinctions between different types of aliphatic hydrocarbons and their varying ecological footprints. Others mistakenly equated aliphatic hydrocarbons solely with fossil fuels, neglecting the existence of bio-based aliphatic hydrocarbons and other sustainable alternatives. Other students held various misconceptions, such as confusing aliphatic hydrocarbons with other organic compounds, struggling to understand isomerism, and believing that all aliphatic hydrocarbons are toxic. These misconceptions were seen as barriers to a more nuanced understanding of aliphatic hydrocarbons and their implications.

Attitudes towards context-based instructions: When discussing context-based instructions related to aliphatic hydrocarbons, students displayed a range of attitudes. Some students viewed context-based instructions as essential for enhancing comprehension and promoting critical thinking about complex topics in aliphatic hydrocarbons. Students appreciated the ability of context-based instructions to provide real-world relevance and practical applications, facilitating a deeper engagement with the subject matter. Few participants, however, expressed skepticism towards context-based instructions, citing concerns about the time and effort required to incorporate context elements into learning materials.

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Opinions on context-based instructions: Among those who expressed opinions on context-based instruction, there were positive responses. Most students advocated for a greater integration of contextual elements in educational materials related to aliphatic hydrocarbons, emphasizing the value of connecting theoretical concepts to tangible examples from everyday life. They believed that such an approach could enhance learning outcomes and foster a more holistic understanding of aliphatic hydrocarbons and their implications. Some students suggested that context-based instructions should be used more frequently, with more emphasis on practical applications and problem-solving. They also recommended incorporating multimedia resources and group activities to enhance learning. On the reverse end of the spectrum, a few participants expressed doubts about the practicality and efficacy of context-based instructions, arguing that in order to guarantee the best possible learning outcomes, a balance between theoretical underpinnings and real-world applications needs to be reached.

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4.1.2 Research question one:

What are students' initial conceptions of aliphatic hydrocarbons?

Research question one focused no assessing the initial conceptions of students in aliphatic hydrocarbons.

Table 1 represents a summary of students' responses from interviews and observation made which sought information on students' initial concepts of aliphatic hydrocarbons.

Table 1: Rating students' interest and misconception in hydrocarbons.

Item	Yes	%	No	%
I have a separate teacher for organic chemistry	0	0.0	30	100.0
The topic aliphatic hydrocarbon is interesting and easy.	3	10.0	27	90.0
The topic aliphatic hydrocarbon is difficult.	26	86.7	4	13.3
I absent myself from class.	27	90.0	3	10.0
I enjoy organic chemistry.	2	6.7	28	93.3
My chemistry teacher makes organic chemistry interesting and fun.	4	13.3	26	86.7
There are many misconceptions in aliphatic hydrocarbons.	28	93.3	2	6.7
I once had misconceptions about some terms in organic chemistry.	1	3.3	29	96.3
Reading chemistry textbooks help me clarify some concepts in organic chemistry.	6	20.0	24	80.0
I understand the fundamental concepts aliphatic hydrocarbon and able to apply them.	4	13.3	26	86.7

Table 1 shows that none of the students had a separate teacher for organic chemistry. About 10% of the students believed that the topic of aliphatic hydrocarbon was interesting and easy while 86.6% believe that it is interesting but difficult. Also, 6.7% of students enjoyed organic chemistry and 63.3% thought otherwise. Only 13.3% thought that their

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chemistry teacher made organic chemistry interesting and fun while 86.7% were of the view that their chemistry teacher made it boring. Majority (93.3%) of the students believed that organic chemistry has many misconceptions whereas only 6.7% believed otherwise. Again, 96.3% of the students once had a misconception in organic chemistry whereas 3.3% never had. About 20% were of the view that reading chemistry textbooks helps them to clarify some concepts in organic chemistry while 80% disagreed.

Major findings from research question 1

Teaching and learning before the intervention were largely based on lecturing which provided no room for students to be actively engaged during lessons. With this teaching method, teacher explained while students listened and copied notes. Most students did not enjoy organic chemistry and had no interest in learning it. Students were of the view that their teachers' attitudes in particular towards organic chemistry could have affected their academic performance in organic chemistry.

The purpose of the study was to use context-based instructions to enhance the performance of final year students of Winneba senior High School in aliphatic hydrocarbons lessons.

From the responses of the students during the interview, it was evident that several factors affected how organic chemistry was taught and learned at Winneba senior high school. Most of the students pointed out that they do not get the chance to ask questions or have discussions with their colleagues and teacher during lessons. Hence, they saw organic chemistry to be difficult and not interesting so failed to enjoy organic chemistry as observed in the study by Sibomana et al. (2021). According to their output, particularly the pre-test, the students first showed disinterest, absenteeism, poor memory of fundamental concepts, and an inability to apply what they learned. Students were unable

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to depict structural equations or even their isomers in two dimensions as a student stated during the interview that; *The position of the double bond and triple bond are most of the times confusing, because I sometimes place these bonds between the numbered carbon and the one to its left and other times, to the right*. Also, another student stated that; *Aliphatic hydrocarbon involve complex molecular structures and reactions, which makes it difficult to visualize and understand*. Retaining and using fundamental ideas is important for the study of organic chemistry since it allows for a smooth transition to creating conceptual frameworks. From the interview, most students mentioned that their teachers used inappropriate teaching methods, were unfriendly, and passed scathe comments. These negative attitudes of teachers put students off as observed in the study of O'Dwyer and Childs, (2017). Additionally, students showed a lack of scientific vocabulary, making it difficult for them to communicate theoretical and observable occurrences with the proper scientific language. Student attempts to reading chemistry textbooks could not help clarify some misconceptions in organic chemistry. Given that over 90% of the students expressed no interest in studying organic chemistry, their performances were quite poor. Such established attitudes might be a factor in learners' failure to succeed (Coll, 2014; Hanson, 2017a). Students' slow attitudes to organic chemistry before the intervention may be blamed for their inability to retain previously taught topics. The majority of students preferred to focus on the physical and inorganic components of their chemistry course since they found organic chemistry to be challenging and frustrating to learn.

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4.1.3 Research question two:

What are students' attitudes towards the use of context-based instruction in teaching aliphatic hydrocarbons?

The purpose of research question two was to assess the attitudes of students towards the use of context-based instructions in teaching aliphatic hydrocarbons.

Table 2 represents a summary of students' responses from interview and observations made during lessons which sought information on students' attitudes towards the use of context-based instruction in teaching aliphatic hydrocarbon.

Table 2: Rating students' opinion and attitudes toward context-based instruction.

Items	Agree	%	Not sure	%	Disagree	%
I asked questions to show my level of understanding.	23	76.7	4	13.3	3	10.0
I contributed massively to the lessons.	26	86.6	2	6.7	2	6.7
I was able to understand concepts.	28	93.3	2	6.7	0	0.0
I was able to apply the concepts taught.	25	83.4	1	3.3	4	13.3
I can explain concepts taught to my colleagues.	22	73.3	5	16.7	3	10.0
I like the teacher's teaching style.	25	83.4	4	13.3	1	3.3
I enjoyed the lessons taught.	27	90.0	3	10.0	0	0.0
I was actively engaged in class activities	22	73.3	5	16.7	3	10.0
I see organic chemistry as part of my daily life.	26	86.6	2	6.7	2	6.7

Table 2 shows that 76.7% of students asked questions to show their level of understanding whereas, the rest were of different opinion. Twenty-six students (representing 86.6%) were of the view that they contributed massively toward the lessons taught using context-

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based instructions while 6.7% think otherwise. About 93.3% and 83.4% were of the view that they understood concepts and were able to apply them respectively. Twenty-two students (representing 73.3%) believed that they could explain concepts taught to their colleagues while 10.0% disagreed. Also, twenty-five students (representing 83.4%) liked the teacher's style of teaching and 90.0% thought they enjoyed the lessons taught. More students (86.6%) believed that organic chemistry was part of their daily lives, 6.7% were not sure about that, whereas 6.7% disagreed with that. It was observed that students were actively engaged in class activities, they demonstrated collaboration and effective communication skills.

Major findings from research question 2

Students were actively engaged in class activities and willingly participated as they perceived that organic chemistry was easy and interesting. It was also observed that context-based instructions used during lessons had impacted positively on the confidence of students as they were able to exhibit collaboration and effective communication skills. Students held the thought that context-based instructions would make organic chemistry easier to learn and remember so as to solve everyday problems and problems in other science subjects.

On students' attitudes to organic chemistry during and after the intervention, most students came to believe that organic chemistry is interesting and easy, as about 90.0% enjoyed organic chemistry more than other branches of chemistry after the intervention. One student stated, *I now know that organic chemistry is everything we use in our daily life after you taught us aliphatic hydrocarbons and I now believe that organic chemistry is very interesting and easy to understand*. Another also state that, *I now understand why oil is always at the surface of water when mixed together and also, why most of the fuel*

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we use for car and cooking at home are hydrocarbons. This appears to suggest that most chemistry students after the intervention have a favourable attitude toward organic chemistry. As observed by the researcher and from responses during the interview, students' attitudes and performance increased when context-based instruction was implemented. This improvement confirms Hanson's (2017a) assertion that, context-based instruction enables students to verbalize, discuss, and explain scientific processes, thereby improving their performance academically. In the lessons, pre-lesson activities were presented at the beginning of the lessons. This frequently required thinking back on earlier concepts to predict the likely outcomes. It made it possible to connect previously taught concepts to those that were anticipated to be learned. This promoted active, pleasant class discussions because students frequently viewed themselves in more amiable settings before progressively focusing on the chemistry concepts in the context. In a way, they moved onto the chemistry platform from well-known contexts. They then had to return to these familiar environments to evaluate how chemistry had influenced them. Majority of the students understood the concepts that were taught in the organic chemistry lessons when explanations were related to real life examples. They agreed that this helped them to think deeply, allowing them to analyze situations and search for concepts accordingly as also found by Yilmaz et al. (2022) in their study. As observed by Wu (2003), in an earlier study, the context-based instructions made the organic chemistry concepts more meaningful to students in this current study. Additionally, students demonstrated strong abilities in cooperation and communication, as found in an earlier study by Hanson (2017a).

Students generally appreciated context-based instructions, finding them engaging and helpful in understanding complex concepts. They valued the use of real-life examples and visual aids.

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4.1.4 Research question three:

What is the effect of context-based instructions on students' performance in aliphatic hydrocarbons?

Research question three was formulated to evaluate students' performance after the use of context-based instructions to teach aliphatic hydrocarbons.

Null hypothesis

H_{O1}. There is no statistically significant difference between students' academic performance in hydrocarbon before and after the use of context-based instruction.

Table 3 shows the results from the analysis of pre-test and post-test scores of students using paired two sample t-test.

Table 3: Paired two-sample t-test on the pre-test and post-test scores of students.

Group	N	Mean	SD	DF	t-cal	t-cri	Remark
Pre-test	52	68.58	9.89	51	3.33	2.01	Significant
Post-test	52	72.71	10.75				

Significant at ($p= 0.002 < 0.05$)

Table 3 was used to test H_{O1} which states that; *there is no significant difference between students' academic performance in hydrocarbon before and after the use of context-based instruction.* The result shows that the t-test calculated value of 3.33 is higher than the t-test critical value of 2.01 at 0.05 alpha level of significance. Hence, the null hypothesis was rejected while we fail to reject the alternative hypothesis which states that; *there is significant difference between students' academic performance in aliphatic hydrocarbons before and after the use of context-based instructions*. This means that there was a

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statistically significant difference between students' academic performance in the concept of aliphatic hydrocarbons before and after the intervention.

The researcher then calculated the Cohen *d* to know the effect size, the result is as shown in Table 4

Table 4: Cohen *d* results for pre-intervention and post-intervention tests.

	Pre-intervention test	Post-intervention test
Mean	68.58	72.71
Standard deviation	9.89	10.75
Cohen *d*	0.40	

From Table 4, the Cohen *d* value of 0.4 means there is a moderate effect size which means the effect that context-based instruction had on students' academic performance was moderate. In other words, there is a medium statistically significant between the performance of students before and after the intervention. Cohen suggested that $d = 0.2$ be considered a "small" effect size, 0.5 represents a "medium" effect size and 0.8 a "large" effect size (Hattie, 2016). Since the calculated Cohen *d* (0.4) is close to 0.5 than 0.2, it is considered medium effect size (Almarode et al., 2021). According to Hattie (2009; 2016), in educational research, the average effect size is ($d = 0.4$) and suggested that the values 0.2, 0.4, and 0.6 be considered small, medium and large effect size respectively.

Major findings from research question 3

Students' performance improved after the intervention. This implies that students showed better performance in the organic chemistry lesson taught using context-based instruction approach. Students believed that knowledge of organic chemistry helps them understand things happening in the world around them when they get to understand the concepts very well.

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Before the intervention, it was discovered that students had false beliefs (misconceptions) about organic chemistry. Some of these were that alkanes of large surface area should have smaller boiling point compared to alkanes with small surface area whiles some of the students thought that hydrogen atom can link two carbon atoms to form aliphatic hydrocarbons; hence, the need for the use of context-based instruction which proved a significant difference between students' academic performance in organic chemistry before and after the use of the intervention. This improvement is shown in Table 3 of which the t-calculated value of 3.33 which is greater than the t-critical value of 2.01 and mean scores of 68.58 and 72.71 for the pre-test and post-test respectively. Since students construct new knowledge with prior knowledge (Cetingul & Geban, 2011), prior knowledge of all topics should be compiled and taken into account while instructing students. Uncovering familiar relationships through discussion of identified misconceptions should be done with a teacher's guidance so that students can socially form their scientific ideas. Without the proper intervention, calling attention to students' misconceptions will not result in conceptual transformation. Students must be actively involved in solving problems, thinking critically, and rearranging old concepts with new ones for learning to be meaningful.

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4.1.5 Research question four:

What is the effect of context-based instruction on the academic performance of male and female students in aliphatic hydrocarbons?

Research question four sought to evaluate the effect of context-based instruction on the academic performance of male and female students in aliphatic hydrocarbons.

Null hypothesis

H_{O2}. There is no statistically significant difference between the academic performance of male and female students in aliphatic hydrocarbons.

Table five shows the results of the analysis of the post-test scores of male and female students using unpaired two sample t-test.

Table 5: Unpaired two sample t-test on the post-test of male and female students.

Group	N	Mean	SD	DF	t-cal	t-cri	Remark
Male	29	72.48	11.33				
				50	0.15	2.01	Not significant
Female	23	73.00	14.05				

Not significant at (p= 0.86 < 0.05)

The result in Table 5 reveals that there is no statistically significant difference between the post-test scores of male and female students in organic chemistry. This, according to the result of the t-test statistics above, shows that the t-test calculated value of 0.15 is lower than the t-test critical value of 2.01 at 0.05 alpha level of significance. Therefore, the null hypothesis which states that*; there is no statistically significant difference between the academic performance of male and female students in hydrocarbon* is retained.

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To evaluate the effect size of context-based instructions on the performance of male and female students, Cohen *d* was calculated and the result is as shown in Table 6.

Table 6: Cohen d results for the performance of male and female students.

	Male students	Female students
Mean	72.48	73.00
Standard deviation	11.33	14.05
Cohen *d*	0.04	

From Table 6, the Cohen *d* calculated was 0.04. This means there is a trivial effect size, so, the effect size of students' sex and their academic performance was negligible. Hence, there is no statistically significant between the performance of male and female students after the use of context-based instruction in teaching aliphatic hydrocarbons. According to Tellez et al. (2015), if the resulting Cohen *d* is less than 0.1, it means there is a trivial effect or the effect size is negligible.

Major findings from research question 4

Comparing the post-test scores of male and female students, there was no statistically significant difference between the post-test scores. This is to say that context-based instruction improves the performance of both male and female students. Students were able to communicate effectively using the right terms and everyday life examples as they worked on assignments in groups. When context-based instruction is used in teaching organic chemistry, the sex of students is not a relevant factor in academic achievement.

On the academic performance of male and female students, it was found that despite the presence of misconceptions, there was no significant difference between the academic performance of male and female students in organic chemistry. This was observed from the t-calculated value of 0.15 which is less than the t-critical value of 2.02 and the mean scores of 72.48 and 73.00 for male and female students respectively. Although, Adamu

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(2004) mentioned the sex of students as one of the factors for poor academic performance, the findings of this current study suggest that the sex of students is not a relevant factor in academic achievement in organic chemistry when context-based instructions are used in teaching aliphatic hydrocarbons. Daluba (2013), and Omwirhiren and Anderson (2016), also revealed that sex is a significant predictor of academic achievement in chemistry with males achieving higher than females while Lawal (2009) found that female students were significantly better than their male counterparts. Researchers in chemistry have discovered that males had higher levels of optimism and self-concept than females (Chan & Bauer, 2015). When it comes to these two factors: emotional satisfaction and intellectual accessibility, women are said to have a less favourable attitude toward chemistry than men do (Brandriet, et al., 2011). This current study's finding supports the findings of Udousoro (2003) and Muhammed (2014) that sex of students does not affect their achievement in science, refuting the findings of Adamu (2004), Daluba (2013), Omwirhen and Anderson (2016), and a few others.

In a different study, it was discovered that using context-based instruction and including specific classroom programmes, like Organic Chemistry in Action (OCIA), improved the learning environment for the students and had a beneficial impact on their attitudes toward organic chemistry (O'Dwyer & Childs, 2014). Such programmes feature discussions, presentations, videos, group and individual assignments. The result also supports the finding of Sani (2010), that there is no significant difference in the level of academic achievement between male and female students in their study of organic chemistry when appropriate teaching methods are employed.

Even though interest in the learning of organic chemistry is a problem for many students all over the country (WAEC, 2018), the case of SHS 3 students at Winneba senior high school was alarming. They were unable to name organic compounds and identify their

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functional groups. In light of the foregoing, it should be the desire of every teacher to assist his or her students to understand the fundaments of organic chemistry to arouse and sustain their interest in chemistry, thereby enhancing their academic performance.

To conclude, the study showed that students' performance in aliphatic hydrocarbons before the intervention was low; however, after the implementation of the intervention, the results of the post-test showed a remarkable improvement in students' performance in organic chemistry. It could, therefore, be said that context-based instruction when employed in teaching and learning of organic chemistry enhances students' performance. From the foregoing, it could also be said that, the research questions were positively answered. The effectiveness of the intervention confirms the findings of Fechner (2009); Pilot (2012); Bilgin et al. (2017); and Hanson (2017a) which stated that context-based instruction enhances students' understanding and performance in chemistry. Additionally, it was discovered that the context-based instructional strategy is an effective teaching option if one wishes to retain gender equality in the teaching and learning of organic chemistry. These results confirm that employing an effective teaching and learning method such as context-based instructions during the teaching and learning of aliphatic hydrocarbon, would enhance the academic performance of both male and female students.

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CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

5.0 Overview

This chapter gives the summary of findings, conclusions, some recommendations, contributions of study to chemistry education, and suggestions for further study.

5.1 Summary of major findings

This research aimed at using context-based instructions to enhance the performance of final year students of Winneba Senior High School in hydrocarbons. The findings of this study were summarized as follows:

1. Most students found the concept of hydrocarbons abstract and challenging to understand.
2. Some students believed that their chemistry teachers made the learning of organic chemistry uninteresting, impacting negatively on their interest in the topic.
3. Students' academic performance in hydrocarbons before the intervention was very low.
4. Most students developed positive attitudes toward the learning of organic chemistry during and after the implementation of the intervention.
5. Context-based instructions had a significant positive impact on students' academic performance in hydrocarbons.
6. Students were able to communicate effectively, using the correct terms and explaining concepts with reference to real-life experiences.
7. There was no statistically significant difference between the performance of male and female students.
8. These findings are consistent with prior research findings indicating the effectiveness of context-based instructions.

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It was found that context-based instructions in chemistry education paved the way for the cultivation of positive attitudes among students. Context-based instructions increased the understanding and application of knowledge in aliphatic hydrocarbons, the development of critical thinking, collaborative skills, and a growth mindset among students. By viewing chemistry education through a contextual lens, teachers can nurture a generation of students who are motivated, engaged, and ready to make a positive impact in society.

5.2 Conclusion

Most students demonstrate difficulty in understanding some organic chemistry concepts. Traditionally designed instruction is dependent on teacher exploration without consideration of students' preconceptions. Instead, context-based instructions are effective to enhance conceptual understanding because students construct their knowledge by making links between their ideas and new concepts through their experience.

Although there were challenges regarding the students' prior knowledge of aliphatic hydrocarbons, findings from the study showed that context-based instruction was able to increase students' performance in aliphatic hydrocarbons. This is parallel with previous studies (Sani, 2010; Hanson, 2017a; Baidoo, 2020) where students were found to achieve higher performance in organic chemistry when context-based instructions were used. Context-based learning has shown to be a more effective teaching and learning technique for teaching organic chemistry in Winneba SHS. The findings of this study lead to the conclusion that the context-based instructional method appears to be more useful for improving the performance of students. Context-based learning encourages mutual interaction by increasing the number of opportunities available for more communication.

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Pedagogically, context-based instructions are conducive to teaching and learning chemistry because they engage learners in meaningful interaction in a supportive classroom environment.

5.3 Recommendations

The following recommendations were made following the outcome of the study:

1. Teachers of Winneba SHS must be encouraged to use context-based instruction to improve students' academic achievement in organic chemistry. In light of the above recommendation, teachers of chemistry in Winneba Senior High School must be trained to use the basic elements of context-based instructions in lesson delivery.
2. With the use of context-based instruction, teachers and students of Winneba SHS can work together to create presentations and projects that will help classroom activities more closely resemble real-world experiences.
3. Organic chemistry lessons should be student-centered so as to have students' full participation. Students should be motivated intrinsically to arouse their interest in organic chemistry.
4. Conceptual change texts are valuable tools in conceptual change learning, so all chemistry textbooks used in the school should be designed according to conceptual change process.

5.4 Contributions of Study to Chemistry Education

1. The findings of this study may be shared with chemistry instructors in senior high schools to persuade them to employ context-based learning strategies for their students' academic success.
2. The Ministry of Education may use these findings as recommendations when revising and improving the chemistry curriculum for senior high schools.

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3. The findings of this study may inspire policymakers to provide adequate financial resources for teacher training programmes that include context-based instruction methodology training.

5.5 Suggestions for Further Study

1. The study should be replicated using larger samples in order to provide strong basis for generalizing the conclusions drawn from the findings of the study.
2. Additional research can be done to determine how well context-based instruction works for additional factors like attitude toward other subjects, self-esteem, peer relationships, social skills, and academic motivation for other subjects.
3. Further research studies should be carried out in other senior high schools in Ghana to examine the differential effect of CBI on male and female students' performance in other chemistry content areas.
4. A study can be conducted to learn how chemistry students see certain teaching methods because their opinion on the use and efficacy of other teaching methods may differ.

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APPENDICES

APPENDIX A (PRE-TEST)

WINNEBA SENIOR HIGH SCHOOL

TEST I

SUBJECT: CHEMISTRY FORM: THREE

DURATION: 30 MINUTES

1. Which member of the following pairs of alkanes has the higher boiling point? Explain the reason.

   (i) Butane and heptane

   (ii) 2- methyl butane and pentane

   (iii) hexane and 2,3- dimethyl propane

   (iv) 2- methyl butane and 2,2- dimethyl propane

2. Give the systematic name of the following molecules.

   (i) $CH_3(CH_2)_5CH_3$

   (ii) $CH_3CH_2CH(CH_3)CH_2CH_2CH_3$

   (iii) $C(CH_3)_4$

   (iv) $CH_3CHClCH_2CH_3$

3. a) State three problems that results from the incomplete combustion of alkane fuels.

   b) Explain why no alkene has only one carbon atom.

4. How does the physical property of hydrocarbon such as boiling points relates to the concept of strength and overcoming challenges?

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5. a) State three uses of ethene.

   b) With the use of bromine water, explain how you will differentiate between an alkane and an alkene.

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APPENDIX B (POST-TEST)

WINNEBA SENIOR HIGH SCHOOL

TEST II

SUBJECT: CHEMISTRY FORM: THREE

DURATION: 40 MINUTES

1. Arrange the following compounds in order of increasing boiling points and give reasons.

   $CH_3(CH_2)_3CH_3$, $CH_3CHCH_3CH_2CH_3$, $CH_3(CH_2)_2CH_3$, $CH_3CHCH_3CH_3$

2. Give the structural formulae of the following compounds

   i) 2,2-dimethyl pentane

   ii) 2-chloro-3,4-dimethyl hexane

   iii) 1,1,2,2-tetrachloro butane

   iv) 1,3-dibromopropane

3. The reaction of bromine with ethane is similar to that of chlorine with ethane. Three steps in the bromination of ethane are shown below.

   Step 1: $Br_2 \rightarrow 2Br^{\cdot}$

   Step 2: $CH_3CH_3 + Br^{\cdot} \rightarrow CH_3CH_2^{\cdot} + HBr$

   Step 3: $CH_3CH_2^{\cdot} + Br_2 \rightarrow CH_3CH_2Br + Br^{\cdot}$

   a) (i) Name this type of mechanism.

   (ii) Suggest an essential condition for this reaction.

   (iii) Steps **2** and **3** are of the same type. Name this type of step.

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(iv) In this mechanism, another type of step occurs in which free-radicals combine. Name this type of step and write an equation to illustrate this step.

b) Further substitution in the reaction of bromine with ethane produces a mixture of liquid organic compounds.

(i) Name a technique which could be used to separate the different compounds in this mixture.

(ii) Write an equation for the reaction between bromine and ethane which produces hexabromo ethane, C_2Br_6, by this substitution reaction.

4. Explain why hydrocarbons are used as fuel for cooking.

5. a) Write the structures of the products obtained when propyne is treated with each of the following reagents.

(I) Conc H_2SO_4 followed by H_2O

(II) One mole of HBr

(III) Excess Br_2/CCl_4

(IV) Ammoniacal copper (I) chloride

b) Three unlabeled liquid samples are shown to be **hexane**, **hex-1-ene** and **hex-1-yne**. With the aid of only two chemical tests, outline how you could identify the samples.

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6. During painting lesson in the visual art class, some students were seen mixing oil paints in water while others used kerosene. Those that used kerosene obtained a uniform mixture and were able to their works but those that used water were not able to do so. Explain the reason they faced these challenges.

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APPENDIX C (SEMI-INTERVIEW GUIDE)

GUIDE FOR SEMI INTERVIEW

1. How have you enjoyed your chemistry class these days?
2. What could be the cause of the change?
3. a) Do you understand what the teachers teaches?

   b) How?

   c) Why?
4. How is your attendance to class like?
5. Do you engage in project works to support the principles that you learn?
6. How are theories learnt and project works connected?
7. Does your teacher alone do activities when teaching?
8. a) Do you like your teacher?

   b) Why?
9. a) Do you expect to perform better or worse in chemistry exercises now?

   b) Why?
10. What were the main problems that were hindering your attitude to chemistry?

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APPENDIX D (MARKING SCHEME (PRE-TEST))

(Test I)

1. i) Heptane: The boiling points of linear alkanes increase regularly with an increasing number of carbon atoms.

ii) Pentane: Boiling point of alkanes with the same molecular mass increases as surface area increases.

iii) Hexane: The boiling point of alkanes with the same molecular mass increases regularly with increasing surface area.

iv) 2-methyl butane: Boiling point of alkanes with the same molecular mass increases as surface area increases.

2. i) Heptane ii) 3-methyl hexane

iii) 2,2-dimethyl propane iv) 2-chloro butane

3. a) CO is toxic or poisonous.

Less energy is produced.

Unburned hydrocarbons react to form compounds which are toxic or harmful.

b) By definition, an alkene is a hydrocarbon with a carbon-to-carbon double bond. Therefore, it must have at least two carbons.

4. Boiling points of hydrocarbons is determined by the strength of intermolecular forces between the molecules. It is the temperature at which hydrocarbons changes from liquid to gas. Hydrocarbons with higher boiling points have stronger intermolecular forces, which require more energy to break and transition

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into the gas phase. Similarly, in the face of challenges, individuals with higher levels of strength can endure and persist through difficult situations

5. a) Manufacturing of polythene.

To prepare ethanol industrially.

Manufacturing of detergents.

Helps is ripening of fruits like banana, orange, lemon since ethene destroys chlorophyll.

As anesthetic when mixed with oxygen.

In production of ethylene glycol used as antifreeze in automobile radiators.

b) An alkene will turn brown bromine water colourless as it reacts with the double bond. Bromine water remains brown in the presence of an alkane as there is no double bond.

$CH_2{=}CH_2 + Br_2/H_2O\ (HOBr) \rightarrow CH_2OHCH_2Br$

Ethene *2-bromo ethanol* (colourless).

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APPENDIX E (MARKING SCHEME (POST-TEST))

(Test II)

1. The intermolecular force in alkane is Van der Waals forces. Van Der Walla forces increases with increasing molecular size and surface area. The greater the Van der Waals forces, the higher the boiling point. Hence the order:

   $CH_3CHCH_3CH_3 < CH_3(CH_2)_2CH_3 < CH_3CHCH_3CH_2CH_3 < CH_3(CH_2)_3CH_3$

2. i) $CH_3C(CH_3)_2CH_2CH_2HC_3$ ii) $CH_3CHClCH(CH_3)CH(CH_3)CH_2CH_3$

   iii) $CH(Cl)_2C(Cl)_2CH_2CH_3$ iv) $CH_2(Br)CH_2CH_2(Br)$

3. ai) Free-radical substitution

   ii) UV light or sunlight

   iii) propagation

   iv) Termination $CH_3CH_2^{\cdot} + Br^{\cdot} \rightarrow CH_3CH_2Br$

   bi) Fractional distillation

   ii) $CH_3CH_3 + 6Br_2 \rightarrow C_2Br_6 + 6HBr$

4. Hydrocarbons are highly inflammable. During combustion of hydrocarbons, they react with oxygen to create carbondioxide, water and heat. The heat produced during this reaction is transferred to the food which helps in the process of cooking.

5. ai) CH_3COCH_3

   ii) $CH_3CBr{=}CH_2$

   iii) $CH_3CBr_2CHBr_2$

   iv) CH_3CCCu

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b) Add bromine in CCl_4 to a portion of each fresh sample. Hex-1-ene and Hex-1-yne decolourise the reddish brown colour of bromine but hexane does not. To a portion of each compound that decolourise add aqueous ammoniacal $AgNO_3$ solution (Tollen's reagent). The formation of white precipitate indicates the presence of hex-1-yne.

6. Water cannot be used to mix oil paint because oil and water do not mix well; they are immiscible. Painters use solvents like kerosene or turpentine to mix oil paint. These solvents have low polarity, which means they can dissolve the oil in the paint and help to thin it out. Kerosene also has low boiling point, which allows it to evaporate quickly after mixing, leaving the dried oil paint. It helps to achieve desired consistency, texture, and transparency.

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APPENDIX F (STUDENTS' SCORES)

Students Raw Scores

No.	Sex	Group	Pre-test scores	Post- test Scores	No.	Sex	Group	Pre-test scores	Post- test scores
1	Male	1	50	72	27	Female	4	70	68
2	Female	5	90	86	28	Female	7	75	94
3	Female	6	68	55	29	Female	3	67	66
4	Female	1	77	81	30	Female	6	73	85
5	Male	2	71	60	31	Male	8	80	76
6	Male	1	80	82	32	Male	2	60	49
7	Male	4	55	50	33	Female	5	52	58
8	Female	3	82	90	34	Male	1	81	82
9	Female	4	60	55	35	Male	7	64	57
10	Female	2	49	56	36	Male	3	80	94
11	Male	1	64	70	37	Female	4	73	97
12	Male	5	75	71	38	Female	2	80	87
13	Female	1	74	75	39	Male	7	79	77
14	Male	3	73	90	40	Male	4	80	82
15	Male	4	70	76	41	Male	2	62	57
16	Female	8	70	69	42	Male	4	74	70
17	Male	3	72	66	43	Male	6	53	58
18	Female	7	70	81	44	Female	3	63	66
19	Male	5	80	83	45	Female	1	61	72
20	Female	6	50	48	46	Male	3	74	83
21	Male	7	59	75	47	Male	6	50	77
22	Female	8	66	80	48	Female	2	73	80
23	Female	5	53	54	49	Male	5	66	64
24	Male	7	72	70	50	Male	8	68	79
25	Male	8	69	80	51	Male	2	60	69
26	Female	8	72	76	52	Male	6	77	83

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APPENDIX G (OBSERVATION CHART)

Five-point scale of observed attitude towards context-based instructions.

The observation was done using the following rating:

1= not at all 2= very little 3= a little 4= a lot 5= a very great deal

Item	1	2	3	4	5
a) Students asked questions to show level of understanding					
b) Students contributed to the lesson					
c) Students were able to explain concepts using real life examples					
d) Students were always present in class					
e) Students were able to apply the concept taught in solving problems					
f) Students were able to use the right vocabulary while answering questions					
g) Students gave structured explanation through higher order thinking					

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APPENDIX H (INTRODUCTORY LETTER)

UNIVERSITY OF EDUCATION, WINNEBA
FACULTY OF SCIENCE EDUCATION
DEPARTMENT OF CHEMISTRY EDUCATION

12th February, 2023

Winneba Senior High School

Winneba

Central Region

Sir/Madam,

LETTER OF INTRODUCTION

CRISPIN KOBINA NYAMEKYE BAIDOO

I write to introduce to you, Mr. Crispin Kobina Nyamekye Baidoo who is pursuing an MPhil in Chemistry Education in the Department of Chemistry Education, University of Education Winneba. He is taking Research **Utilizing context-based instructions to teach hydrocarbons in organic chemistry** as his theses topic.

I would be very grateful if you could give him the necessary assistance he may require.

This is purely for academic purpose.

Thank you for your cooperation.

Yours faithfully,

DR. EMMANUEL K. OPPONG
AG. HEAD OF DEPARTMENT