AKENTEN APPIAH-MENKA UNIVERSITY OF SKILLS TRAINING AND ENTREPRENEURIAL DEVELOPMENT

COMPARETIVE EFFECT OF REACT AND 7E INSTRUCTIONAL APPROACHES ON CHEMISTRY STUDENTS' ACADEMIC PERFORMANCE IN NOMENCLATURE OF ORGANIC COMPOUNDS

SIMON PETER MAHAMA ATONGO

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BY

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A thesis submitted to the School of Graduate Studies, Akenten Appiah-Menka University of Skills Training and Entrepreneurial Development in partial fulfillment of the requirements for the award of a Master of Philosophy degree in Science Education

MAY, 2024

DECLARATION

Candidate's Declaration

I, hereby declare that this thesis is the result of my own original work and that no part of it has been presented for another degree at this university or elsewhere.

Simon Peter Mahama Atongo

Signature: …………………………………. Date:…..……………………………

Supervisors' Declaration

We hereby declare that the preparation and presentation of the thesis were supervised in accordance with the guidelines on supervision of thesis laid down by the Akenten Appiah-Menka University of Skills Training and Entrepreneurial Development.

Prof. Emmanuel Dartey

Signature: …………………………………. Date:…..……………………………

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ABSTRACT

This study sought to explore the effectiveness of the REACT instructional strategy, 7E Instructional model, and conventional teaching method on students' achievement in nomenclature of organic compounds in three public S.H.S in sekyere, Kumawu District. By adopting quasi-experimental pretest/posttest non-equivalent two experimental control groups design, three intact classes comprising of 147 SHS Chemistry students were sampled for the study. The instrument used to collect data in this study was Organic Chemistry Nomenclature Concept Test (OCNCT). Using independent sample t-test to answer the research questions, results showed that students taught using REACT teaching strategy (M = 24.43, SD = 2.335) performed better than those taught using the conventional teaching method (M = 18.15, SD = 2.093; t(96) = 14.000, p - .000), and those taught using 7E Instructional model (M = 23.93, SD = 2.296) also performed better than those taught using the conventional teaching method (M =18.15, SD=2.093; t(95) = 12.949, p =.000). Also, there was a significant difference ($F_{(2,144)}$ = 69.011, p=0.000<0.05) between students when all three teaching methods were compared. It was therefore concluded that the use of 7E and REACT teaching strategies equally enhance SHS Chemistry students' academic performance in the teaching and learning of nomenclature of organic compounds. It was recommended that SHS chemistry teachers should teach nomenclature of organic compounds using 7E Instructional model and REACT teaching strategy.

ACKNOWLEDGEMENTS

My profound gratitude goes to Prof. Emmanuel Dartey and Dr. Charles Amoah Agyei, my supervisors, for their guidance, encouragement, patience and constant support for this work, may God bless them. Further, I appreciate the support offered to me by the headmasters, teachers, and students of the schools in Sekyere, Kumawu that participated in this study for the assistance they gave to me which helped me in the compilation of this work.

I am very grateful also to my wife, daughter and mother, Mrs. Janet Mahama, Ms. Praise Yinbon Mahama, and Mrs. Badienmal Dock for their love, prayers, support and motivation, my pals; Mr. Kenneth Darko Ateko and Mr. Charles Osei-Owusu for every support they have given to me throughout this study. I will also like to express my gratefulness to God Almighty, for being the source and giver of knowledge and wisdom, Devine providence, support, and grace towards making the compilation of this work successful.

DEDICATION

To my lovely wife, daughter, and mother and to the entire Mahama's family.

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LIST OF ABREVIATION

REACT	Relating, Experience, Applying, Cooperating and Transferring
5E	Engage, Explore, Explain, Elaborate, and Evaluate.
7E	Elicit, Engage, Explore, Explain, Elaborate, Evaluate, and Extend.
S.H.S	Senior High School
WASSCE	West African Senior Secondary School
WAEC	West African Examination Council
SPSS	Statistical Package for Social Science
OCNCT	Organic Compound Nomenclature Concept Test
IUPAC	International Union of Pure and Applied Chemistry
ZPD	Zone of Proximal Development
BSCS	Biological Science Curriculum Study.

CHAPTER ONE

INTRODUCTION

1.0 Overview

This chapter begins with the study's background, as well as the statement of the problem. The chapter also presents the main objective and specific objectives of the study as well as research questions. Also, the significance of the study, delimitations and limitations of this research are highlighted in this chapter. The chapter ends with operational definition of terms used in the study, as well as the organization of the study.

1.1 Background to the Study

Science education is the cornerstone of a country's scientific and technological growth in this highly sophisticated technological world. according to Abimbade *et al.* (2018), the foundation of understanding science subjects in post-secondary institutions is hinged on the understanding of a student gains in the secondary school education. A student's grasp of science and degree of achievement in it are heavily dependent on whether or not they have sufficient knowledge, and their ability to perform adequately in the subject of not only Biology and/or Physics, but also Chemistry. Chemistry is thus, crucial to the study of science since majority of scientific concepts relate to the structure of matter and offer a thorough justification and help students to comprehend an occurring chemical occurrence (Anim-Eduful & Adu-Gyamfi, 2022). Chemistry, according to Anim-Eduful & Adu-Gyamfi (2022) is the area of science that investigates the traits, composition, and structure of substances, also known as elements and compounds, as well as the transformations they undergo and the energy that is either released or absorbed. This means that, Chemistry deals with the composition, properties and reactions of matter. But, all compounds, whether created through natural processes or manmade means, contain one or more of the atom species classified as elements (Çelikler *et al.*, 2017), implying that atoms are also the fundamental building blocks of chemical substances.

The application of Chemistry can be observed in both domestic and industrial situations like in the fields of cooking, fermentation, glassmaking, and metallurgy. According to Ministry of Education (2010), Chemistry is also necessary for the creation of everyday products like soap, plastics, books, radio, TV, video, and computers. Also, Chemistry can help us understand, rationalize, control, and prevent events like bushfires, industrial pollution, metal corrosion, and ozone layer loss. As a result, studying chemistry in school is crucial because it is a subject that is fundamental to life. The need for a fundamental knowledge of compounds and chemicals cannot be overstated because it is critical for our safety. We should use caution while handling many of the chemicals we come into contact with on a daily basis because they have the potential to be very reactive.

The study of organic chemistry consists of the structure, properties and reactions of organic compounds, which contain covalently bonded carbon atoms, extending to an understanding of chemical reactions in organisms and their products (Adu-Gyamfi & Asaki, 2023). According to Adu-Gyamfi & Asaki (2023), studying the structure of organic compounds reveals the understanding of their chemical composition and formula whereas the properties entails physical and chemical properties, and evaluation of chemical reactivity to understand their behavior. Therefore, organic chemistry serves as the foundation for all living things (Sibomana *et al.*, 2020) because carbon is now known to form a seemingly unlimited number of compounds in living organisms and non-living materials (Nartey & Hanson, 2021). Thus, Organic chemistry plays an important part in our daily life because it is the study of organic reactions that leads to the synthesis of food, clothes, paper, ink, rubber, soap, perfumes, medicines, fuels, natural gas, medicine, pesticide, fertilizers, paint, candles, plastic, etc., which are products of organic compounds, are indispensable to us for proper living. Additionally, studying organic chemistry is crucial for students who want to become pharmacists or chemists so they can create medications that lessen human suffering. To aid in the discovery and extraction of oil, natural gas, and other organic substances with commercial applications, the petroleum sector will also need organic chemists. To create novel goods like solvents and polymers, chemical and process engineers will work with organic chemists. Also, forensic analyst, food scientist, amongst a host of others are various professions associated with the studies of organic chemistry. Therefore, decisions regarding pursuing a professional or academic career in the biomedical and associated sciences may be influenced by poor organic chemistry performance, which would put the medical and chemical sectors of the economy into jeopardy (Davis, 2016 and Donkoh, 2017b).

Nomenclature of organic compounds, which refers to a system of naming organic compounds, is a key concept in organic chemistry, hence, the comprehension of virtually every other topic in chemistry, including carbon compounds, proteins, polymers, acids and bases, chemical energy, and thermodynamics, is contingent upon having a firm grasp of it (Adu-Gyamfi *et al.,* 2017; Ministry of Education, 2010). Authorities established nomenclature to help in communication on chemical compounds, including their structures, characteristics, and applications, as stated by

Hartshorn and Yerin (2019). As a result, the International Union of Pure and Applied Chemistry (IUPAC), an organization that seeks to give Chemistry a universal language, was founded in 1919. However, according to Sibomana *et al.* (2020), Nomenclature is still regarded as a challenging topic to teach and study. Also, Adu-Gyamfi et al. (2017), reported that Senior High School Chemistry students struggle to understand the concept and principles nomenclature of organic compounds. According to Adu-Gyamfi *et al.* (2017) the students exhibited poor performance on naming and writing structural formulae for alkenes, alkynes, alkanols, alkanoic acids, and alkyl alkanoates. Nartey and Hanson (2021), Donkoh (2017a), and Davis (2016) all found the naming of organic compounds as one of the many concepts in organic chemistry which were perceived by students as difficult to understand. Numerous times, the West African Examination Council (WAEC) Chief Examiners' Reports in Ghana bemoaned how difficult it was for most students to respond to examination questions about the IUPAC nomenclature of organic compounds in the West Africa Senior Secondary Certificate Examination (WASSCE) (WAEC, 2017, 2018, 2019, 2020).

The employment of inappropriate instructional methods in the teaching of topics in Chemical formulas and nomenclature is one of the leading causes of the difficulties connected with learning these concepts (Anim-Eduful & Adu-Gyamfi, 2022; Mayeem *et al.,* 2018). Other reasons have been attributed to the abstract nature of the concept of nomenclature (Hartshorn & Yerin, 2019), leading to poor attitude towards the learning of the concept (Donkoh, 2017b; Kaya & Gül, 2021). Given that teachers are ultimately in charge of putting policies into practice and principles based on interaction with the students, it has been demonstrated that the instructional strategies they use in the classroom have a significant impact on students' performance, which is also crucial in overall educational attainment (Ajayi, 2017). It is generally agreed upon that the primary weakness in Chemistry instruction stems from instructors' inability to effectively put into practice the teaching techniques they have been taught, primarily relying on the less efficient model of teacher-centered learning (Saka, 2011). The significance of carefully thought-out instructional methodology in the teaching of nomenclature of organic compounds cannot be emphasized given the complexity and abstraction of such concepts (Ministry of Education, 2010). As a result, according to Twizeyimana *et al.* (2020), successful teaching and learning of Chemistry requires a thorough understanding of how to choose the optimal pedagogical method, lesson plan, and other pedagogical tools.

There are basically two approaches to teaching that can be distinguished: the teacher-centered approach and the learner-centered approach (Ubulom & Ogwunte, 2017). A learner-centered teaching approach, according to Lak *et al.* (2017), puts the learner at the center of the learning process, whereas in the teacher-centered teaching approach, also known as "conventional teaching method" the teacher becomes the main actor in the learning process and that the classroom teacher takes the stage of the learning process and places themselves at the center. However, the paradigm of teaching and learning is currently shifting from teacher-centered teaching approach, to the more enhanced learner-centered teaching approach.

This is because, an active learning environment is produced by student-centered teaching, where teachers are seen as facilitators and students as active learners (Bekenova & Nygatayeva, 2017). Students are guided by the teacher to construct their own knowledge and understanding of concepts in the classroom. That is, the teacher designs the lessons to suit the needs of the learners. This indicates that students are actively engaged in the learning process and take ownership of their education. The emphasis of a learner-centered teaching approach is on how students learn rather than how teachers teach (Lak *et al.,* 2017). This consequently helps learners to have a rich understanding of concepts, hence improving their academic performances. However, in the teacher-centered classroom, students become passive recipients of teachers' knowledge (Lak *et al.*, 2017), and only listen to the teacher "talk and chalk" (Romanus & Ifenyinwa, 2020). Thus, the teacher becomes a repository of knowledge, directly providing information or knowledge to students. By this approach, all curriculum-related decisions, instructional strategies, and assessment options are made by the instructor.

One indicator of the teacher-centered teaching approach is rote-memorisation, where students learn by repetition so as to remember every word verbatim (Bekenova & Nygatayeva, 2017). Because of this, students soon forget concepts being taught since they learned it abstractly (Felder & Brent, 2017). According to the Senior High School Chemistry teaching syllabus, teachers are encouraged to employ student-centered instructional strategies that will aid in the students' understanding of concepts. However, students continue to lament on the abstract nature of nomenclature of organic chemistry (Adu-Gyamfi *et al.*, 2017). This could be attributed to the fact that classroom teachers are unable to select the appropriate student-centered instructional approach.

As a result, this study intends to compare the effectiveness of the REACT teaching strategy and the 7E instructional approach on Senior High School Chemistry students' achievement in IUPAC nomenclature of organic compounds. REACT teaching strategy is a context - based teaching strategy that enables students construct and use knowledge in science. A context-based approach seeks to establish linkages between the scientific information and the setting of real-world problems (Ültay *et al.,* 2017). According to Ültay et al. (2017), courses that use a context-based approach encourage students to participate and offer promise for increasing their interest in learning chemistry and their perception of its relevance. Context-based learning emphasizes application through cases and real-world examples from students' outside of the classroom lives (Günter, 2018). This method, according to Günter (2018), encourages knowledge construction rather than memorization on the part of the students. This means that, in order to facilitate effective learning, context-based approaches leverage themes and applications that students may connect to their own cultures, daily routines, families, and social networks. Furthermore, a context-based approach benefits students' lives and the lives of others throughout the world while assisting them in developing a deeper awareness of the environment. "REACT" is an acronym which involves the stages of Relating, Experiencing, Applying, Cooperating, and Transferring.

The term *"relating"* describes the process of learning in the light of prior information or personal experiences. This implies that recent discoveries are connected to events in our everyday lives. Learning by doing, exploring, finding, and creating is what is meant by "*experiencing*." The objective is to give students exposure to experiences that are closely connected to work in the real world. Thus, activities at this stage help students put abstract ideas into concrete form. Comparatively, "*applying*" refers to learning by the application of theories and bits of information. That is, putting the newly acquired information or knowledge into practice. Through assignments, activities, lab work, text, and videos, students apply ideas and knowledge in practical contexts. Learning that is shared, discussed, and communicated with other students is referred to as "*cooperating*." Group activities, including as projects, hands-on research, problem-solving, and analysis of plausible scenarios that students undoubtedly encounter on a regular basis might accomplish this. "*Transferring*" is utilizing information in a different context (Günter, 2018; Ültay *et al.,* 2017).

Teachers assist students in discovering their own conceptual knowledge through activities in the classroom. The application of the teaching process uses real and contextual resources that are pertinent to the study areas of the students. As a result, learning is accomplished through student practice and application of their knowledge in various activities and applications (Özbay & Kayaoglu, 2015). Studies have been conducted to determine the effectiveness of the REACT teaching method in Chemistry concepts. Günter (2018) found that students' performance in solubility equilibrium was enhanced by the REACT teaching strategy. Also, Ültay *et al.* (2017) discovered that the REACT teaching strategy was more successful in clearing students' alternative conceptions in solution chemistry. Kaya and Gül (2021) also found a positive attitudinal change and motivations towards the study of biology due to the use of REACT strategy. The 7E learning model is an inquiry-based, student-centered teaching method, that uses a variety of activities to provide the groundwork for students to conceptualize information correctly.

This teaching method consists of seven phases, which are; Elicit, Engage, Explore, Explain, Elaborate, Evaluate and Extend (Shuaibu *et al.,* 2021). During the "*elicit phase*", the teacher emphasizes students' prior knowledge and comprehension of the subject matter which is yet to be learnt (Adesoji & Idika, 2015). Existing knowledge, according to Juliana *et al.* (2021), which Marfilinda et al. (2020) are also in agreement, serves as a foundation for the development of new knowledge that will probably be applied to new domains. The "*engagement phase*", Juliana *et al.* (2021) assert, is designed to focus learners' attention on what has to be learned. This is accomplished by using quick tasks that get their brains working, which piques their attention and makes them more willing to acquire new material. By utilizing strategies like "think-pair-share," the instructor makes sure all children have the chance to voice their thoughts with their classmates. During the "*exploration phase*", students have the opportunity to manipulate items, observe and record data, isolate variables, design and conduct experiments, create graphs, interpret results, establish hypotheses, and arrange their findings. Learners have the opportunity to collaborate while studying concepts and skills. Throughout this time, the teacher monitors the research the pupils are conducting and makes sure they are actively developing new ideas (Juliana *et al.*, 2021; Marfilinda *et al.*, 2020). At the "*explanation phase"*, the teacher assists students with developing clear scientific language and asks them questions that will help them utilize these terminologies to explain the findings of their investigations. The teacher urges the learners to articulate concepts in their own words while attentively hearing the arguments made by their peers.

While the teacher gauges the students' developing comprehension of the novel topics, learners are given the chance to create their own knowledge (Juliana *et al.*, 2021). The "*elaboration step*" helps learners develop their conceptual knowledge. The student applies previously taught concepts to new areas through additional tasks. As a result, learning is transferred since students are using what they have learned in new situations. Their practical abilities are therefore improved, which deepens their comprehension of the new concept (Juliana *et al.,* 2021). The teacher evaluates students' conceptual comprehension both summatively and formatively during the "*evaluation phase*". To achieve this, the instructor assesses how well the learning objectives have been met. Additionally, self-evaluation is encouraged for students. The instructor can evaluate the pupils using questions, mind maps, and data interpretation (Juliana *et al.,* 2021). The "*extension phase*", which was really added to the elaboration phase, is to expressly create some form of awareness in teachers of the value of having pupils practice applying what they have learned. The application of information in new contexts and not just simple elaboration are two things that teachers need to ensure (Adesoji & Idika, 2015). This means that, here, students are asked to ponder, discover and describe instances of how recently learned ideas and abilities have been put to use (Marfilinda *et al.,* 2020). For example, finding application of the rate of chemical reactions to topics such as aerobic and anaerobic respirations, photosynthesis, digestion, etc. The 7E instructional model's implementation enhances knowledge transfer, retention, attitude and maintains learners' interest in the teaching and learning process, thus improving students' academic performance (Marfilinda *et al.,* 2020). From the above background, both 7E Instructional Model and REACT teaching strategies have been found to enhance students' academic performance. However, to determine the appropriate teaching approach between the two teaching approaches in the study of nomenclature of organic compounds, literature appears to be silent, thereby providing a gap to be filled, highlighting the need for this study.

1.2 Statement of the Problem

The study of nomenclature, according to the Ministry of Education (2010), is the foundation to understanding most topics in Chemistry including acids and bases, carbon compounds, thermodynamics, chemical energy, proteins and polymers. Nomenclature, according to Hartshorn and Yerin (2019), was introduced in Chemistry to facilitate communication about chemical compounds, their structures, properties, and uses. As a result, the International Union of Pure and Applied Chemistry (IUPAC), an organization that seeks to give Chemistry a universal language, was founded in 1919.

Sibomana *et al.* (2020) conclude that, nomenclature of organic compounds is still regarded as a challenging topic in Chemistry to teach and study. Also, in Ghana, Nartey and Hanson (2021), Donkoh (2017a), Davis (2016) and Adu-Gyamfi et al. (2017), reported that, Senior High School students struggle to understand the concept and principles of nomenclature of organic compounds. Recent WAEC chief examiners' reports highlight how difficult it was for most candidates to respond to examination questions regarding the IUPAC nomenclature of organic compounds (WASSCE) (WAEC, 2017, 2018, 2019, 2020). Research suggests that, the employment of inappropriate instructional methods in the teaching of topics in chemistry is one of the leading causes of the difficulties connected with learning these concepts (Anim-Eduful & Adu-Gyamfi, 2022; Mayeem *et al.,* 2018), which makes the subject too abstract for students to study (Hartshorn & Yerin, 2019).

Twizeyimana *et al.* (2020), assert that the success of Chemistry teaching and learning depends on knowing how to select the best pedagogical approach. According to the Ministry of Education, 2010, Senior High School Chemistry teaching syllabus, teachers are encouraged to employ student-centered instructional strategies that will aid in the students' understanding of concepts (Ministry of Education, 2010). The REACT teaching strategy and the 7E instructional model have been found individually, to help students concretize abstract concepts, consequently, improving students' academic performances in Chemistry. However, little studies apparently exist regarding their comparative study. As a result, this study intended to compare the effectiveness of the REACT teaching strategy, 7E instructional approach, and the conventional teaching method, on SHS Chemistry students' performance in IUPAC nomenclature of organic compounds.

1.3 Purpose of the Study

The main aim of study was to determine the comparative effect of 7E instructional model, the REACT teaching strategy, and conventional teaching method on Senior High School Chemistry students' academic performance in the nomenclature of organic compounds.

1.4 Specific Objectives of the Study

The specific objectives of this study were to determine:

1. the difference in performance between students taught nomenclature of organic compounds using the 7E instructional model and those taught through the conventional approach.
2. the difference in performance between students taught nomenclature of organic compounds using the REACT instructional strategy and those taught through the conventional approach.
3. the difference in performance between students taught nomenclature of organic compounds using the 7E instructional model, the REACT instructional strategy and the conventional approach

1.5 Research Questions

1. What is the difference in performance between students taught nomenclature of organic compounds using the 7E instructional model and those taught through the conventional approach?
2. What is the difference in performance between students taught nomenclature of organic compounds using the REACT instructional strategy and those taught through the conventional approach?
3. What is the difference in performance between students taught nomenclature of organic compounds using the 7E instructional model, REACT instructional strategy and the conventional approach?

1.6 Significance of the Study

First of all, this study should enlighten Sekyere, Kumawu District Chemistry teachers about the necessity of using appropriate student-centered instructional strategies that will raise students' academic performance. Second, this study provides information to chemistry teachers in the district in their quest to select the appropriate teaching methods in the teaching and learning of nomenclature of organic compounds. Also, this study should help instructors in the district that train teachers about the necessity of emphasizing student-centered ways to teaching more in order to raise students' academic performance.

1.7 Justification of the Study

There are a number of individual research studies on the 7E instructional model and the REACT instructional strategy, but it seems not much studies have been conducted on comparative research on REACT, 7E and conventional teaching approaches, especially in Ghana, to help classroom instructors decide which learner-centered instructional strategy is appropriate to use to help Chemistry students perform well academically in nomenclature of organic compounds.

1.8 Delimitations of the Study

The functional groups that were taken into consideration were alkanes, alkenes, alkynes and alcohols, but not all functional groups in organic chemistry were considered in the study. These topics were examined since reports from WAEC and other researchers have shown that they are the functional groups students frequently find difficulty naming their compounds. Also, the study was limited to SHS three elective chemistry students from Sekyere, Kumawu District since organic chemistry is studied in SHS 3 per the SHS chemistry syllabus. Another restriction was that while a quasi-experimental approach was used, not all schools in the Sekyere, Kumawu District were able to take part in the research. Also, since quantitative approach was adopted in this study, only quantitative data analyses techniques were employed.

1.9 Limitations of the Study

Since participants in this study were not completely randomly assigned to experimental and control groups, generalisations about other populations could not be made using the findings of this study.

1.10 Operational Definition of Terms

Academic Performance – the degree to which a learner has fulfilled their immediate learning objectives, and is measured by a test, an assignment, a project or an examination.

Organic chemistry – the study of the structures, properties, compositions, reactions, and preparation of carbon containing compounds.

Organic compound – a compound of carbon atoms bound to one another and other atoms by covalent bonds (single, double or triple bonds), which are found in living organisms.

Teaching method – the overarching principle, pedagogy, and classroom management techniques employed in teaching.

1.11 Organisation of the Study

The research is structured into five chapters, each of which concentrates on a distinct aspect of the topic. Chapter one included the following topics: the study's background, problem statement, purpose, research questions, hypotheses, significance, delimitations, limitations, and definitions of terms. The literature relevant to this topic was reviewed in chapter two. This includes conceptual review of the study, theoretical review, and empirical review. The third chapter emphasises on the methodology of the study, which includes research design, population, sampling procedure and sample, data collection instruments, data collection techniques, and data analysis. Chapter 4 contains the results presentation and a discussion of the findings. Chapter five contained the study's summary, conclusions, recommendations and suggestions for further research.

CHAPTER TWO

LITERATURE REVIEW

2.0 Overview

A review of the literature that is relevant to this study is presented in this chapter. The review of literature in this chapter were categorised as theoretical review and conceptual review, which talked about the various concepts that were related to this study. These concepts are REACT teaching strategy, 7E Instructional model, and the conventional teaching approach, which are the teaching methods. Under the teaching methods were teacher-centered and student-centered teaching methods. The chapter also considered the concept of academic performance, the concept of organic chemistry, as well as students' difficulties in organic chemistry. All these concepts were conceptualised in the conceptual framework of the study. Additionally, review of previous studies related to this study was also highlighted in this chapter. The chapter thus ends with summary of the reviewed literature.

2.1 Theoretical Review of the Study

This study is grounded in constructivism theory. According to Bada (2015), the learning theories of Dewey, Piaget, Vygotsky, Gagne, and Bruner solidified the constructivist learning theory. Constructivism is predicated on the philosophy that people actively construct their own knowledge, and that reality is shaped by the experiences of learners. Therefore, Jack (2017) explains that students bring unique experiences to the classroom each day, and their background and past knowledge affect how well they learn. Thus, educators can assist students grasp their prior knowledge by utilising constructivist learning theory. To constructivists, man is not "tabula rasa" or blank slate (Bada, 2015), hence, students connect newly learnt material to their past knowledge to build upon it. This means that each person's learning is distinct due to their own experiences.

Constructivism is a philosophy whose use in the classroom is influenced by its unique components and tenets. To begin with, constructivism warrants that knowledge is created. and that knowledge is built upon itself. Therefore, students choose parts and put them together in unique ways to produce unique creations that differ from those made by other students. The learner's past knowledge, experiences, beliefs, and insights establish essential foundations for their future education. Also, constructivism holds that learning is an active process, which involves sensory input to make meaning. That is, in order to take an active role in their own learning and growth, learners must interact with the outside world. Students cannot be passive and expect to be fed with information regarding what they are learning; however, they must participate in activities, discussions, etc.

Another principle of constructivism is that, learning is a communal endeavor. Our capacity for learning is intimately related to our social interactions. Teachers, family, and acquaintances all have an influence on our learning. Thus, since progressive education recognises that engagement with others is crucial to learning, it uses group applications, conversation, and interaction to help students retain their knowledge. Again, constructivism operates on the principle that learning is contextual. Learners acquire knowledge in ways that are related to their prior knowledge, beliefs, and more. They do not pick up solitary ideas and facts that are cut off from the rest of our existence. There is a relationship between what pupils learn, what they generally retain, and what goes on around them. Golder (2018) asserts that Jean Piaget and Lev

Vygotsky are associated with cognitive constructivism and social constructivism, respectively. Jean Piaget's study of children's intellectual development is the foundation of cognitive constructivism.

According to Piaget (1976), learning should be adapted to the learner's intellectual stage. Consequently, it is necessary to create classroom environments and activities that support individual learning (Powell and Kalina, 2009). By establishing connections between the new and what they already know, these teaching techniques support students' acquisition of new information and help them adapt their innate intellect to the new knowledge. Piaget's theory of cognitive development posits that people should acquire information on their own rather than being given facts they can use right away. As highlighted by Powell and Kalina (2009), Based on case-based observation, Piaget came to the conclusion that human cognition develops via interaction with the environment, but in a consistent, physiologically required order, leading to knowledge and abilities that are adaptively structured. These cognitive phases evolve in an inherently complicated, organic manner toward adaptive usefulness, coexisting with other emerging behavioral and emotional traits. He identified four fundamental stages of cognitive development: (a) early childhood, when sensory-motor schemas begin to form; (b) early childhood, when pre-operational schemas (representations) begin to form; (c) mid-childhood, when concrete schemas (logical operations) begin to form; and (d) late childhood, when formal schemas (operations on hypotheticals) begin to form.

According to Powell and Kalina (2009), Piaget's discoveries about these developmental stages are realized through the acquisition of particular schemas (regimens, skill sets, protocols), which are initially related to the needs of the individual but can later be applied through analogy to novel experiences, situations, or scenarios. When previously adaptive schemas show to be insufficient for a child's demands, significant structural repairs to the knowledge base are required, the kind that signal a behavioral stage-shift. This inadequacy creates a cognitive dissonance that encourages the kid to engage in exploratory actions that lead to a more gratifying relationship with the environment, thereby supporting the next developmental stage. Piaget assumed a dynamic (although ultimately structured at every given moment) knowledge foundation that needs to be adjusted in order to develop. A knower's knowledge base can expand and change as a result of the adaptive mental processes of assimilation (fitting new information to match existing knowledge) and accommodation (altering existing knowledge to fit new information). According to Piaget, intelligence arranges itself in order to organise the outside environment. Social constructivism emphasises how learning is a collaborative process. This was the theory of Vygotsky in the late 1970's. Vygotsky viewed the construction of knowledge through human interactions with one another, their culture, and society as a whole.

Because learning is a collaborative process, students depend on others to help them establish their building blocks, and learning from others aids in the creation of their own reality and knowledge. Social constructivism and cognitive constructivism are closely related theories that incorporate peer and social influence (Aljohani, 2017). According to Vygotsky, learning conditions benefit from the combination of participation and acquisition. Aspects of participation included discussions, engaging in class debates, small-group collaborative learning with projects and assignments, and prioritizing meaningful action over accurate responses. Students may find significance in these circumstances based on their social and personal backgrounds. Social constructivism therefore places a strong emphasis on the fact that learning occurs through interactions with other students, teachers, and the wider world (Bozkurt, 2017). According to Vygotsky, language and culture have a significant role in shaping people's worldviews and intellectual development. In other words, concepts are transferred through language and subsequently interpreted and understood through experience and interactions within a cultural framework (Akpan *et al.*, 2020).

Vygotsky believed that, when learners are assisted through collaborative interactions during the instructional process, they are able to develop their potentials to manifest into reality. This led to the introduction of the term “Zone of Proximal Development (ZPD)” by Vygotsky (1978). Vygotsky’s "zone of proximal development" describes a spectrum of activities that are too challenging for learners to complete on their own but that they can master with help and direction from adults or more experienced peers (Kalpana, 2014). ZPD helps to identify the parts of a child's mind that are still developing but have not reached their full potential. These are the kind of functions that are only getting started today but will reach their full potential tomorrow. Rather than concentrating on what the student is now capable of, the teacher should highlight the student's potential.

The ZPD goes through a number of inner development processes that ultimately lead to independent achievement. There is a complex link between the processes of instruction and development, which are two separate processes. According to Vygotsky, effective instruction should push for the reactivation of a group of functions that are in the maturation stage and are located in ZPD. In this manner, teaching has a significant impact on growth. In his subsequent arguments, Vygotsky made the claim that teachers are in charge of providing the atmosphere for learning in which instruction takes the initiative and steers development (Vygotsky, 1978). Since this is the case, educators should enter ZPD as and when necessary. A significant means has been examined, called "scaffolding", a concept that is crucial to the sociocultural framework (Topçiu & Myftiu, 2015). The term "scaffolding", as Topçiu & Myftiu (2015) explain, means 'to create a scaffold' or to offer external assistance by means of a building's construction. The procedure for moving from teacher aid to independence is referred to as scaffolding. That is after demonstrating a method or task for learning, the teacher hands off responsibility to the students. The use of scaffolding gives instructors' classroom teaching strategies a theoretical foundation. Scaffolding strategies include demonstration, breaking down a task into smaller steps, giving instructions, maintaining focus, giving examples and asking probing questions, separating content into digestible chunks, and more.

2.1.1 Relationship Between 7E Instructional Model as well as REACT Teaching Strategies and Constructivism

Constructivism calls for individuals to be more responsible and engaged during the process of learning since it is predicated on the idea that every type of learning is realised through a mental production process. This is the major underlying principle in both 7E Instructional model and REACT teaching strategies. By employing these strategies, students are given the opportunities to investigate the content through series of hands-on activities as revealed by Crawford (2001) and Eisenkraft (2003). These activities, according to constructivists, will challenge students' previous knowledge and help reveal any misconceptions or alternative conceptions which they carry to the classroom. This will consequently pique students' interests and attention to the material or content to be learned.

Another major principle of constructivism is cooperative learning. Students that participate in cooperative learning collaborate in small groups to enhance both their own and each other's learning. As Vygotsky (1978) stated, when a student interacts with more experienced and more capable people, in a collaborative learning environment, learning becomes effective. This is inherent in both REACT teaching strategies and 7E Instructional model. The teacher operates as a facilitator during the learning process and only providing assistance, guidance or clues to learners when they become stagnant and do not know what to do. In this case, the teacher applies a concept Vygotsky called "scaffolding". That is the teacher identifies the students' "zone of proximal development" and provides support for students to manifest their potential achievements.

2.2 Conceptual Review of the Study

2.2.1 REACT Teaching Strategy

The REACT teaching strategy is a teaching and learning strategy which deals with the concept of contextualization proposed by Crawford. Contextual learning, according to Herlina and Ilmadi (2022) is a concept of learning that can assist teachers in relating topics taught to the outside world and motivate students to create connections between their knowledge and day-to-day experiences. The REACT teaching strategy encourages students to learn through hands-on activities and daily life examples (Utami *et al.,* 2016). The teaching strategy requires students to learn the subject matter through five stages, which are explained below.

Relating – This is the first stage of the REACT teaching strategies, and at this stage, teachers use their experiences and past knowledge to inform what students learn. The learners' interest is piqued by examples from daily life, and these examples are then connected to the new ideas that need to be learned. According to Crawford (2001), even while students may bring memories or past information to a new learning environment, they might not realize how significant it is. By applying the "relating stage", the teacher starts class by posing questions or issues that students can resolve based on their prior knowledge and experience. Rather than transmitting an abstract idea or a phenomenon that is outside the scope of the students' perceptions, understandings, and knowledge, the questions are always about phenomena that students find engaging and familiar (Musyadad & Avip, 2020; Quainoo *et al.*, 2021). Crawford (2001) adds that, students that successfully make the connection enjoy a "aha" moment when they get virtually instant insight.

Experiencing – During this stage, as they study in the environment of creation, investigation, and discovery, students have the chance to partake in actions that are connected to actual events in real life. This is the stage which Crawford (2001) termed as "learning by doing". That is, teachers provide a supporting environment and the requisite materials for students to explore the learning material by themselves. Students learn best if they manipulate tools and materials and other forms of media in active learning, which can enable them to apply concepts they learn in their real lives. As a result, Marlan (2017) argues that, students are expected to be able to apply the theories they have studied into the context of practical application in order to help them understand the concepts better. Therefore, what they encounter in class has a significant impact on how well they understand the teachings that have been taught by the teacher.

The experiencing stage can include the use of manipulation, problem solving and other hands-on activities in the laboratory. This will also help clear any misconceptions students carry to the classroom, as well as increasing their motivation and attitude to learn the subject (Marlan, 2017; Musyadad & Avip, 2020; Quainoo *et al.,* 2021).

Applying – During this stage, opportunity is given to students to put to use what they have learned (Quainoo *et al.,* 2021). At the applying stage, through class activities, labs, and project work, students put the fresh ideas they have learned or the knowledge they have acquired in practical perspective. Although, teachers can utilise hands-on problem-solving activities, like in the "experience stage", they can also encourage students to understand the material by giving out activities that are pertinent and realistic. These exercises, according to Crawford (2001) can be "word problems", but they must make use of actual scenarios and show how academic ideas can be applied to some aspect of a person's daily life. A too simple task will get students bored and make them lose interest and motivation in learning new concepts, while a too difficult task, which is beyond students' capabilities will stifle students' progress, and may cause them to lose confidence in learning the concept. In-between tasks, or those that are challenging but reasonable allow students to make legitimate progress while creating new knowledge.

Cooperating – When a student learns alongside other students, they are cooperating. In this context, Özbay and Kayaoğlu (2015) highlight that students share, respond and communicate with other learners. Therefore, according to Crawford (2001) teachers that use student-led groups to perform exercises or practical activities are implementing the "cooperation" strategy. Crawford (2001) adds that complex problem-solving exercises are common, especially when they incorporate real-world scenarios. It is occasionally impossible for students working alone to make meaningful progress on these issues during a class hour. If the teacher does not offer detailed instructions, they could feel frustrated. However, when students are working in small groups, they are frequently able to solve these challenging issues on their own, with little help from the teacher. Students assess and reformulate their own ideas by listening to others in the group. Because an alternative approach to the issue could at times be more effective, they learn to value other people's perspectives. When a group of students works together to accomplish a task, they are more motivated and confident than when they work alone.

Transferring – At this stage, students learn by applying recently taught ideas in a brand-new situation, which they have never encountered throughout the lesson (Quainoo *et al.,* 2021). In other words, students' existing knowledge and skills are not merely memorized; they may also be put to use in different contexts. The mastery of cognitive methods or accomplishment of learning objectives is measured by how well students can use the knowledge they have acquired to solve new challenges (Musyadad & Avip, 2020). According to CORD (2016), it gives learners confidence to approach new situations and challenges by teaching them how to apply previously learned information to new contexts.

From the foregoing, it can be said that REACT learning strategies can be utilized to engage students in the process of developing their own knowledge, which necessitates interaction with the environment. But these activities are undertaken under the guidance of the teacher.

2.2.2 7E Instructional Model

The 7E Instructional model is also another student-centered teaching method which allows learners to construct their own meanings from the concepts taught in the classroom through varieties of activities under the guidance of the teacher (Shuaibu *et al.,* 2021). This means that, students are urged to investigate a topic and deepen their comprehension of it while dispelling any misconceptions and organizing their thoughts. The learning cycle model was proposed by Eisenkraft (2003) and was born as a development of 5E instructional model which was also proposed by the Biological Science Curriculum Study (BSCS) led by Rodger Bybee. The 7E learning cycle model, like the REACT teaching strategies, also emphasises examining the learner's prior knowledge, as well as embracing cooperative learning, whereby students engage in conversation, cooperation, and interaction in an effort to completely comprehend a newly introduced concept, which Shuaibu *et al.* (2021) iterate are the hallmark of every student-centered learning. According to Bybee *et al.* (2006), the 5E Instructional model consists of the following five stages, which are; "engage", explore, explain, elaborate, and evaluate". However, the proposed 7E model by Eisenkraft (2003) expands the "engage" element into two components — "elicit" and "engage". Similarly, the 7E model expands the two stages of "elaborate" and "evaluate" into three components— "elaborate", "evaluate", and "extend". Eisenkraft asserts that, these modifications are not meant to make things more complicated; rather, they are meant to make sure teachers do not leave out essential components of their lectures because they believe they are following the rules of the learning cycle but are instead omitting them. The "elicit" and "extend" phases were added in order to emphasise the growing significance of reinforcing prior understandings and applying the concepts to novel contexts throughout lessons. The modifications of the 5E Instructional model to 7E Instructional model is shown in Figure 1.

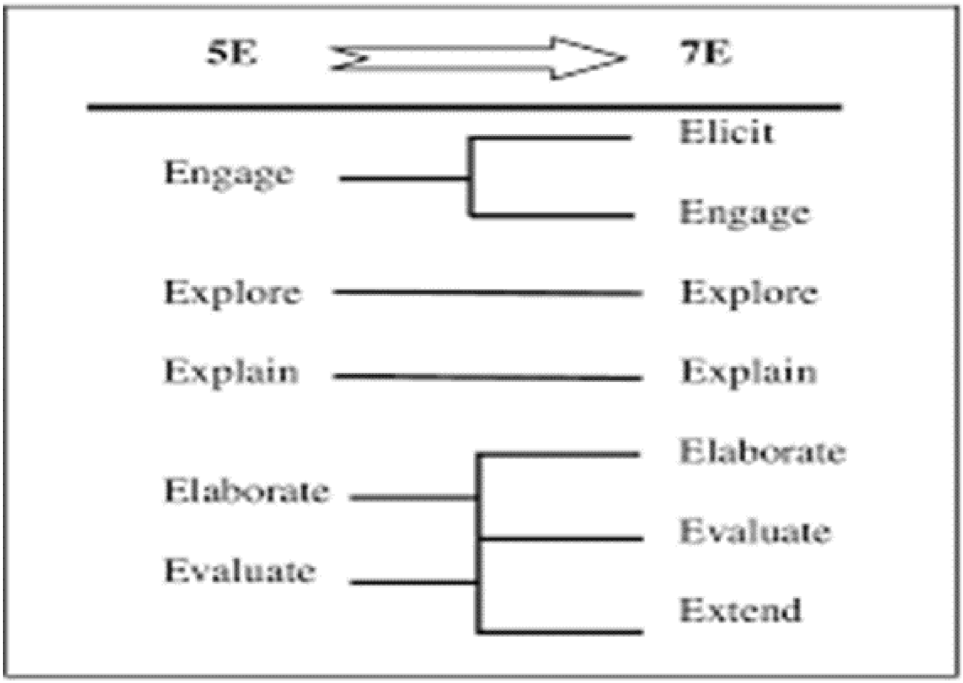


Figure 2.1: Proposed 7E Instructional Model (Adopted from Eisenkraft 2003)

The various stages of the 7E Instructional model are explained below.

Elicit – The goal of the "elicit" phase is to get students to recall prior knowledge that is related to the new information (Bülbül, 2010). That is, teachers probe pupils' past knowledge during the elicit phase and identify any misconceptions they may have. According to Eisenkraft's (2003), inclusion of the “elicit phase” is grounded on the idea that, in order to emphasise the significance of elicitation in meaning construction and learning, the “elicit phase” should be included separately and not as part of the "engage" phase as Bybee *et al.,* (2006) proposed. Eisenkraft wrote “teachers may excite students, get them interested and ready to learn, and believe they are fulfilling the engage phase of the learning cycle, while ignoring the need to find out what prior knowledge students bring to the topic". According to Eisenkraft, the objective is to uncover preconceived notions while continuing to engage and thrill learners in every way that is feasible. One means by which Eisenkraft suggests teachers may use to elicit prior understandings is by framing a "what do you think" question at the beginning of the lesson, using practical real-world problem which students are familiar with.

Engage – During the engage phase, teachers employ an experiment or a different activity to get pupils interested, ask questions, and keep them occupied (Balta & Sarac, 2016). That is, this stage focuses student thinking on content. The activities, according to Bybee *et al.* (2006), should draw connections between previous and present learning experiences, in addition to exposing preconceived notions and organizing students' thoughts toward the learning objectives of the current activities. If students look puzzled, expressing "How did that happen?" or "I have wondered about that," and "I want to know more about that," they likely are engaged in a learning situation (Bybee *et al.*, 2006).

Explore – The explore phase gives students the chance to observe, gather information, identify variables, plan and conduct experiments, make graphs, analyse data, formulate hypotheses, and arrange their findings. Teachers have the ability to pose questions, offer strategies, give criticism, and evaluate how well students understand things (Eisenkraft, 2003). Bybee et al. (2006) state that through shared activities, exploration experiences give students a foundation for identifying misconceptions, processes, and abilities that they currently use, as well as for facilitating conceptual change.

Explain – In the explain stage of the learning cycle, models, laws, and theories are introduced to the students. Students interpret findings in terms of these recently developed ideas and models. The instructor helps students develop unique scientific vocabulary, steers them toward coherent and consistent generalisations, and offers questions that support their use of this vocabulary to explain the findings of their investigations (Eisenkraft, 2003). Eisenkraft (2003) assert that the difference between the stages of "explain" and "explore" guarantees that ideas come before words.

Elaborate – Students have the chance to apply their knowledge to new domains during the elaborate phase of the learning cycle, which may involve posing fresh questions and ideas for investigation. Students may also be required to answer related numerical problems during this period (Eisenkraft, 2003). Students gain more knowledge, appropriate skills, and a deeper, wider understanding through new experiences (Bybee *et al.*, 2006).

Extend – Teachers challenge and expand learners' conceptual knowledge and abilities at this stage. Eisenkraft (2003) termed this phase as "practicing the transfer of learning". To Eisenkraft, the purpose of the extend phase's addition to the elaborate phase is to specifically remind teachers of how important it is for students to practice applying what they have learned. Instructors must ensure that knowledge is applied in novel contexts and is not restricted to straightforward clarification.

Evaluate – Assessments of students' learning, both formative and summative, form the learning cycle's evaluate phase, as Bybee et al. (2006) asserted. The evaluation phase can take the form of diverse assessments such as test, and the tests, as Eisenkraft (2003) maintains. Students can be required to analyse data from a lab that is comparable to the one they finished, or as a component of their evaluation, students might also be required to develop experiments. Eisenkraft (2003) continues that There should not be a linear cycle. As a result, formative assessment needs to happen in every encounter with learners. One type of formative assessment is the activities done in the elicit phase. There must always be strategies used in conjunction with the explore and explain phases by the teacher to ensure that the students have understood. Additionally, substituting elaborate and evaluate with elaborate, extend, and evaluate highlights the fact that learning transfer, which is essential in the extend phase of the learning cycle, can also be utilized in the assessment phase (Eisenkraft, 2003).

2.2.3 Conventional Teaching Method

Olifer (2020) asserts that, before the adoption and acceptance of placing the student at the center of the instructional process, the teacher-centered paradigm was the norm, which is why it can be referred to as “conventional or traditional method”. The term "conventional teaching method" therefore describes the traditional method of instruction , which typically involves the teacher dispensing information to students through the use of lectures or narration and minimal discussions (Appiah-Twumasi, 2020). That is, with this method, the teacher orally delivers the content and answer questions from the students. Here, the main focus is on recalling and applying knowledge of facts, rules, and learning theories, where instruction is delivered in a way that encourages learners to sit still and listen (Appiah-Twumasi, 2020; Tularam, 2018). This stands to reason that, in a conventional classroom, the teacher controls and modifies the flow of knowledge. However, according to Murphy et al. (2021), through homework and assignments, students are expected to continue to deepen their understanding of a subject outside of the classroom. In this case, the instructor, who exclusively teaches face-to-face, is the principal resource for the students, who then determines students' comprehension through standardized tests and examinations. Therefore, in this model, the time, place, and pace of the students' learning stay constant.

Researchers including Sawant and Rizvi (2015), Achor et al. (2019), Appiah-Twumasi (2020), Djami and Kuswandon (2020), have noted some shortcomings of the conventional teaching method, amongst which include rote learning or memorization, lack of problem-solving skills, lack of critical thinking skills, less inclusivity, where lessons are not modified to suit every learner in the classroom, as well as competition and individualistic learning among learners, where students only study to pass tests and examinations and aim to prevail as best students among their colleagues. However, Abah (2020) argues that classroom instruction cannot completely do away with the conventional teaching method but maintains that classroom teachers should improve education by incorporating all ways and tactics that are most appropriate for particular circumstances and provide the highest chance of achieving predetermined goals. In line with Abah's (2020) position, Altun (2023) also noted that when it comes to imparting a lot of knowledge in a short period of time, the traditional teaching approach is more effective. Additionally, teacher-centered education is sometimes thought of as being more orderly and predictable, which can be advantageous for students who have trouble learning on their own.

2.3 The Concept of Academic Performance

Academic performance indicates how well an individual has performed in respect to certain goals that were the main focus of activities in educational environments, such colleges, universities, and schools. (Abanikannda, 2016). The most significant result of formal education is thought to be academic performance (Moore, 2019). The metrics used to quantify academic performance determine its definition. Academic performance can be measured in a variety of ways. The curriculum-based which include grades and test scores, the more broadly based which include procedural and declarative knowledge acquired throughout education, and the degrees and certificates which form the cumulative aspect (Boonk *et al.*, 2018; Peng & Kievit, 2020). The commonality across all the criteria is that they are intellectual endeavors, which fundamentally reflect an individual's capacity for thought. Thus, academic performance can be considered the outcome of learning. A student's ability to continue their education is determined by their performance on class exercises, tests, assignments, projects, and end-of-semester exams in Ghanaian secondary high schools.

Students receive marks ranging from A1 to F9. As a result, a student's academic standing indicates whether they are eligible for further education, and the degrees they earn have an impact on their post-educational career. Academic success is critical to a country's wealth and prosperity in addition to its personal significance (Ceylan & Kesici, 2017). This is because, when students perform well academically, they are likely to achieve the best outcomes in the educational process, which will invariably affect the human resource of the nation's economy. That is, the nation's economic sectors will be manned by individuals who are deemed competent, by virtue of their academic success.

2.4 Teaching Methods

Teaching method refers to all of the instructional methodologies, managerial strategies, and general pedagogy used in the classroom. The way a teacher presents the material to a class is referred to as the pedagogy of teaching. That is, giving students knowledge in a systematic manner. According to Al-taai (2021), a teaching method is a set of deliberate and intentional activities designed to control a student's cognitive and practical activity and ensure that the learner understands the material being taught. Juuti *et al.* (2010) also explain teaching methods as strategies that teachers can employ to simplify the process of instruction and encourage students' interest in the subject matter. Thus, it can be said that, for a student to learn a concept taught in the classroom, the teacher must find a way to help the student understand the concept taught. That is, the teaching method a teacher employs for the lesson is important in the student's ability to realize the concepts. According to Juuti *et al.* (2010), teaching methods offer students the chance to study in a way that is motivating, enjoyable, and engaging. They support educators in carrying out their duty to support students' social and emotional growth. The appropriate teaching methods can help educators establish respect, empathy, and cultural sensitivity in their students. Learning outcomes may fluctuate in a variety of ways depending on the teaching methodology used. This means that, not all teaching methods are effective for every single lesson. Consequently, while it is the duty of the instructor to guarantee that learning is effective, one crucial approach to do so is through utilizing effective teaching methods.

Generally, what guides a teacher to adopt a particular teaching method is how the teacher sees the process of learning, thus, how learners construct knowledge. This according to Cathcart *et al.* (2020) is known as the philosophy of teaching. Based on a teacher’s teaching philosophy, teaching methods can be grouped into teacher-centered and learner-centered.

2.5 Teacher-centered Teaching Method

Teachers who use this approach of instruction choose the material they want to teach, organize their lesson plans, and then evaluate their students' learning (Schreurs & Dumbraveanu, 2014). Appiah-Twumasi (2020) emphasises that the ability of students to tell, memorise, and recall information is the main focus of this kind of instruction. That is, because asking and responding to questions is essentially their only duty, students in a teacher-centered classroom are severely constrained. The majority of the time while using teacher-centered teaching techniques, learners learn by listening passively. The instructor is at the center of all that happens in the classroom. In the teacher-centered approach to education, the teacher is the information provider and the source of all knowledge.

Here, Appiah-Twumasi (2020) continued that concepts are taught by teachers mostly through lectures and little discussion. The instructor explains and clarifies those ideas, writing pertinent equations and keywords on the whiteboard. Following the teachers' explanations, the themes are addressed through teacher-directed questions, during which the students take notes. As a result, rather of being active learners, the pupils in this classroom scenario are most likely passive learners. With this idea of teaching, the instructor may appear to be instructing, but in actuality, they may not be imparting much knowledge. It is possible that the pupils are not learning at all, or that even if they are, what they're learning has already been processed and won't help them further develop their developing minds.

2.6 Student-centered Teaching Method

In this method, there is a shift of focus on the teacher to the student (Schreurs & Dumbraveanu, 2014). According to Schreurs & Dumbraveanu, the learners actively create knowledge and even share in its construction. They are given real-world challenges to address in a socially and collaborative setting, and they use their expertise and experience to construct knowledge and to solve the problems. The learning environment now encompasses not only the classroom but also the business, home, and so on. Put differently, the learning environment places more emphasis on student responsibility and activity than it does on instructor control and the comprehensiveness of the academic information covered in most traditional, didactic training. Additionally, subjects that are pertinent to students' needs, interests, and lives make learning more meaningful for them, as do situations in which they are actively involved in knowledge creation, comprehension, and connection.

With the learner-centered approach, the learning process prepares the learner for the lifelong learning. Lifelong learning refers to the continuous process of gaining knowledge, skills, and competencies throughout one's life, with the aim of improving personal and professional development. Appiah-Twumasi (2020) adds that instructors that use this kind of instruction are viewed as coaches and facilitators who help students discover things on their own. To put it another way, the instructor's job in student-centered classrooms is to urge students to participate actively in their learning by encouraging them to make more discoveries and to learn from one another. To do this, the instructor concentrates on creating engaging, real-world assignments. Thus, the emphasis of student-centered teaching approaches is on the needs, requirements, interests, and developmental capacity of the students.

2.7 The Concept of Organic Chemistry

The term organic literally means "derived from living organisms." (Wade, 2013, p.1) Therefore, in organic chemistry, chemicals that are exclusively found in living things are studied. Atoms of carbon and hydrogen, or carbon and hydrogen combined with a few other atom kinds like oxygen, nitrogen, and sulfur, make up organic molecules. Because carbon atoms can create strong covalent bonds with one another and link together to form straight chains, branching chains, and rings, carbon is the subject of special study. The great variety and quantity of organic molecules can be attributed to the almost unlimited bonding configurations of carbon atoms. That is, of all the elements, carbon is the only one that can produce such a vast variety of compounds, starting with the basic methane (the chief constituent of natural gas) with one carbon atom, to the complex DNA, which can have more than 100 million carbons (McMurry, 2013; Petrucci *et al.,* 2011). Organic chemistry therefore, is the study of carbon compounds. Special groups known as functional groups exist in organic chemistry. Organic molecules possess unique features due to the attachment of individual or groups of atoms called functional groups to their carbon chains or rings (Anim-Eduful & Adu-Gyamfi, 2021). Thus, Chemical characteristics of molecules sharing the same functional group are typically similar. Thus, it is convenient to understand organic chemistry by taking into account the characteristics linked to particular functional groups (Petrucci *et al.*, 2011).

Functional groups in organic chemistry are hydrocarbons, thus, alkanes (functional group with single bonds) alkenes (functional group with double bonds), alkynes (functional group with triple bonds), and benzene (functional group with double bond in ring structures). Other functional groups include alcohols ($-O$H); aldehydes ($-CHO$);

ketones ($-C = O$); carboxylic acids ($-COOH$); esters ($- COOR -$); and amides ($-CONH_2$) Chemistry syllabus (Ministry of Education, 2010), where C represents carbon atom; H represents hydrogen atom; O represents oxygen atom; N represents nitrogen atom. Another important concept in organic chemistry, which is also studied in the SHS is nomenclature of organic compounds. Nomenclature of organic compounds is a systematic approach to naming organic compounds as endorsed by IUPAC (Adu-Gyamfi *et al.*, 2017). To facilitate communication, the IUPAC nomenclature system provides a universal standard for identifying compounds. The goal of the system is to give each structure a unique and understandable name and link each name to a unique and understandable structure (Hartshorn and Yerin, 2019). The foundation of IUPAC nomenclature is the designation of the longest sequence of carbons in a molecule, whether in a straight chain or a ring, joined by a single bond. All deviations are denoted by prefixes or suffixes based on a predetermined set of priorities, whether they involve numerous bonds or atoms other than carbon and hydrogen (McMurry, 2013). In the IUPAC system of nomenclature, a chemical name normally consists of four parts: a prefix, parent, locant, and suffix. The locants indicate the positions of the functional groups and substituents, the suffix identifies the primary functional group, the parent is a major portion of the molecule and indicates how many carbon atoms are in that portion, and the prefix identifies the different substituent groups in the molecule (Petrucci *et al.*, 2011).

2.8 Students' Difficulties in Organic Chemistry

Researchers claim that organic chemistry is a challenging subject that deters students and is linked to subpar performance. For instance, Nartey and Hanson (2021) in Ghana, sought to determine the "*Perceptions of Senior High School Students and Teachers* *about Organic Chemistry*" using hundred SHS 3 students and ten chemistry teachers. It was found that reactions of alkenes, alkynes and benzenes as well as their preparation and structure were considered to be more difficult for students. In order to ascertain the difficulty associated with SHS organic chemistry themes for both the teacher and students, Donkoh (2017a) utilised a descriptive cross-sectional survey design. The study sample was made up 235 students and 13 chemistry teachers. According to the study, chemistry teachers had 14 topics that were challenging to teach and three topics that were easy. Eight organic chemistry topics were deemed difficult to understand by students, while nine concepts related to organic chemistry were extremely difficult for them. Students' perceived reactivity of organic compounds, Petroleum, Benzene, Alkanoic acids, Alkanoic acid derivatives, Amino acid functional groups, Natural and synthetic polymers as difficult topics to understand. Similarly, Davis (2016) and Dwyer & Childs (2017) also reported that aromatic hydrocarbons, as well as reaction mechanisms were perceived as a difficult to topics to learn respectively. Adu-Gyamfi et al. (2017) studied 245 SHS 3 chemistry Students' difficulties in IUPAC naming of organic compounds in the Kumasi Metropolis in Ghana, and their results showed that students had difficulties in naming structural formulae of alkanes, alkenes and alkynes, geometrical isomers, dienes, primary and tertiary alkanols, diols, alkanoic acids, and alkyl alkanoates.

All these difficulties students encounter regularly reflect in SHS final year external exams. For example, the chief examiners WAEC reported that "candidates were unable to draw and name the isomers of butane (C4H8), draw the appropriate diagram to indicate how the C=C double bond in alkene is formed" (WAEC, 2017). Also, in 2018, candidates did not exhibit inadequate knowledge of organic chemistry concepts

(WAEC, 2018); majority of candidates who were able to arrange ethanol, ethane and butane in the correct order of increasing boiling points, but could not explain or give reasons for their answers (WAEC, 2020); and inability of candidates to select organic compound that could be cracked, undergo substitution reactions from a list of compounds (WAEC, 2021). From the foregoing, it can be concluded that SHS Chemistry students really struggle to understand and apply organic chemistry concepts. However, by employing appropriate and effective student-centered teaching method, students will have a better grasp of organic chemistry concepts, and will be able to apply them whenever necessary.

2.9 Conceptual Framework of the Study

This study was guided by the principles of constructivism, where students make meaning of the learning content through active participation in the learning process. By actively exploring and engaging the learning material individually and collaboratively, students' understanding of the subject matter will be increased leading to improved academic performances. Informed by these principles the study's variables were conceptualized as shown in Figure 2.

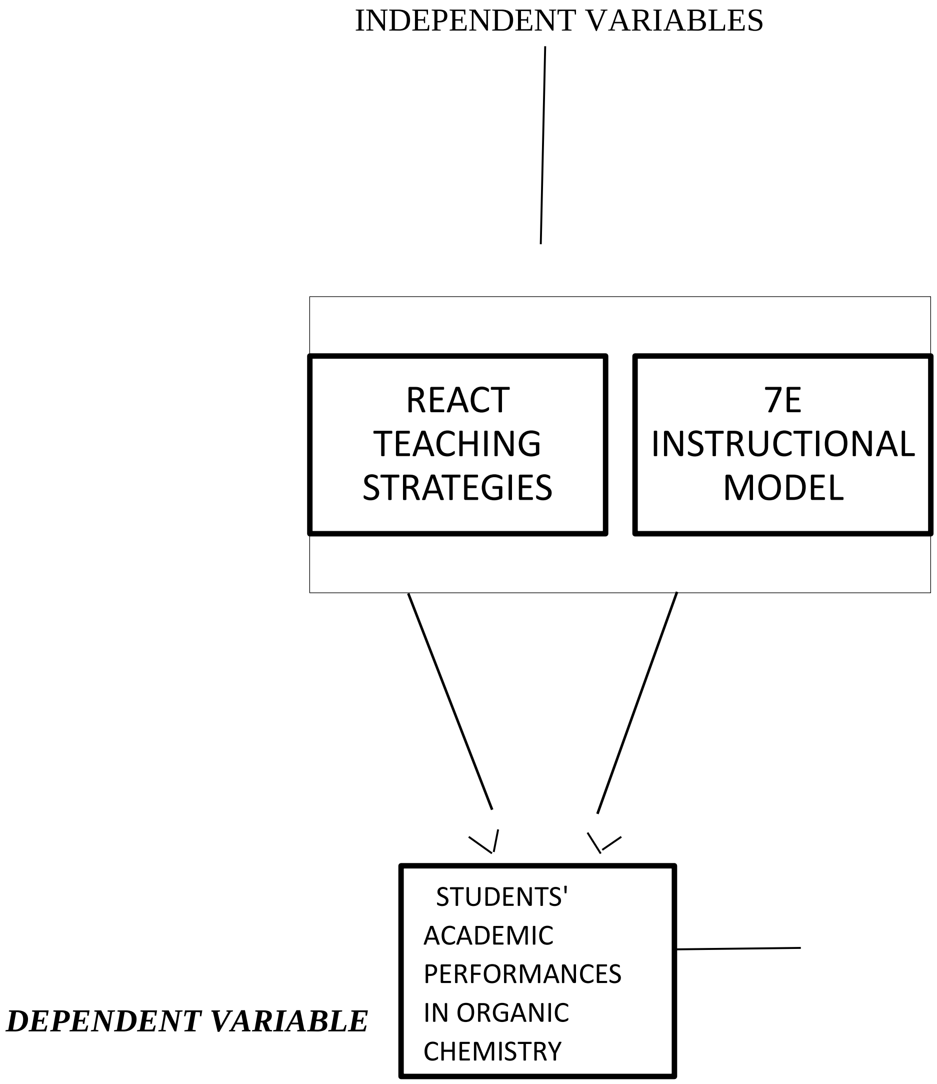


Figure 2.2: Conceptual Framework of the Study

The independent variables were REACT Teaching Strategies and 7E Instructional Model. These variables were conceptualised as factors affecting the dependent variable, which is students' academic performance in organic chemistry. In Figure 2, the teacher plays a role as a facilitator who prepares the instructional content, lesson plan and selects appropriate teaching and learning activities to be undertaken by the students. The learner's role in Figure 2 is to actively perform activities selected by the teacher during the instructional process. Students are not to passively sit in the earning environment listening and observing the happenings in the classroom but are to explore by themselves what the teacher is putting across. By so doing, the instructional methods are then able to influence students' academic performances in organic chemistry.

2.10 Empirical Review of the Study

2.10.1 Empirical Review of REACT Teaching Strategies On Students' Academic Performance

Several studies have investigated the efficacy of the REACT teaching strategies on the academic performances of students. For example, in the study of Quainoo *et al.* (2021) in Ghana, the embedded mixed methods research design was employed, where a qualitative component was embedded in the quantitative design. Fifty-seven (57) SHS 2 elective biology students from two intact biology classes were selected randomly and were assigned into experimental (taught using REACT teaching strategies) and control (taught using conventional teaching method) groups. An independent sample t-test revealed that students taught through REACT teaching strategies performed better (mean=16.48, t=5.647, p=0.001) compared with the conventional group (mean=11.50), with an effect size of 1.52, indicating a large effect size. This indicates REACT teaching strategy is efficient in improving students' academic performance.

Bilgin *et al.* (2017) also ascertained the effect of REACT strategy on Turkish 6th grade students' conceptual understanding in the particulate nature of matter. The authors employed a pre-test – post-test control group design using fifty-five (55) experimental group students (taught through REACT teaching strategies) and forty-seven (47) control group students (taught through 5E instructional strategies). An independent sample t-test revealed significant difference in post-test scores (t=2.29, p=0.024), with the experimental group obtaining a higher mean score (mean =55.27) than the control group (45.53). Their findings also showed that REACT teaching strategies were effective in enhancing students' conceptual understandings.

Akay and Kanadli (2021) conducted a mixed research synthesis including 19 quantitative and 10 qualitative studies. Quantitatively, meta-analysis was used while qualitatively, thematic synthesis was used. The result of the meta-analysis revealed that REACT strategy had a strong effect on performance in science (Effect size= 1.041, p=0.01), indicating that REACT teaching strategies has positive impact on students' academic performances. Günter (2018) assessed REACT strategy's effect on students' achievements in solubility equilibrium, using a quasi-experimental pre-test/post-test nonequivalent control group design. Ninety-six (96) second year students who pursued Medical Laboratory Techniques and Pharmacy Services Programmes were used. A Mann-Whitney U test showed that there was a significant difference between post-test scores in favour of the experimental group ($U = 374.5$, $p < 0.05$). Günter's (2018) finding indicates that the REACT strategy improved students' performance in solubility equilibrium.

2.9.2 Empirical Review of 7E Instructional Teaching Strategy on Students' Academic Performance

The 7E Instructional Model has also been investigated on students' academic performances. Few of these studies are reviewed. For instance, in Indonesia, Marfilinda *et al.* (2020) employed a quasi-experimental pretest/posttest control design in a study titled the impact of 7E Learning Cycle Model on students' learning outcomes in basic science. An independent sample-test revealed that there was a significant difference (t=-2.708, p=0.09) between the two groups with the experimental group (mean=76.0) outperforming the control group (56.39), with an effect size of 0.07, suggesting moderate effect size. This therefore is an indication that, 7E Instructional model has positive effect on students' academic performance.

In the same vein, Shuaibu *et al.* (2021) also employed the quasi-experimental, pre-test, post-test control group design, using two public secondary schools who were randomly assigned experimental (taught through 7E Instructional model) and control (taught through the conventional teaching method) groups. The sample size were one hundred and twenty students, thus, sixty (60) students per group. In this study, an independent sample t-test showed a significant difference between the experimental (mean=72.81, SD=8.91) and control groups (mean=61.2, SD=5.64; p=0.001). Also, the researchers found that the experimental group retained Biology concepts better (mean=65.20) than the control group (mean= 53.67) after a delayed post-test was conducted.

Furthermore, in a study conducted by Juliana *et al.* (2021), a quasi-experimental design was adopted using 346 third year students. Three schools were assigned the experimental group, comprising of one hundred and seventy-one (171) students and three schools assigned the control group, comprising of one hundred and seventy-five (175) students. The study found that there was a statistically significant difference (t= -20.8, p=0.00) between the mean scores of those taught using 7E Learning Cycle Model (mean=49.44, SD=11.59) and those taught using Conventional Instructional Method (mean=26.08, SD=9.99). In Ghana, Gyampoh *et al.* (2021) in their study used forty (40) Junior High School (JHS 2) students thus, twenty (20) students each in the experimental group (taught using 7E Instructional model) and control group (taught using conventional teaching method). An ANCOVA results revealed that, there was a significant difference (p=0.00, F=60.734) between the experimental (mean=66.65, SD=10.00) and control (mean=47.70, SD=7.71) groups. Their findings indicate that, the 7E Instructional model has significant impact in improving JHS academic performances in science.

*2.9.*3 Empirical Review of Comparative Study of 7E Instructional Model and REACT Teaching Strategies

It appears only a single study has been reported in literature regarding a comparative study of 7E Instructional model and REACT teaching strategy. This study was conducted by Quainoo (2019). Three intact classes consisting of seventy-nine (79) students were randomly assigned as the REACT (N=27), 7E (N=22) and conventional (N=30) groups. By employing the embedded mixed method design, data were analysed quantitatively and qualitatively. The quantitative analysis of the posttest scores, using a One-Way Analysis of Variance (ANOVA) revealed that there was a significant difference among the three groups ($F_{(2,76)} = 15.484$, $p = 0.001$). A post-hoc Bonferroni test indicated that the REACT group and the 7E group performed significantly equal. Nevertheless, in comparison to students taught using the conventional approach, those exposed to REACT teaching strategies did better. Similarly, students in the 7E group outperformed the conventional group significantly. From Quainoo's (2019) study, 7E Instructional model and REACT and equally improved students' academic performances in Biology.

2.10 Summary of Literature Review

The literature review showed that both REACT and 7E Instructional model are traced to the constructivism theory. Teachers who employ these teaching strategies adhere to the philosophy that students learn best when they are given opportunities to practice what they learn in the classroom. As a result, REACT and 7E learning strategies are two teaching methods which allow for students to take active part during classroom lessons. Also, the literature review revealed that chemistry students in Ghana and outside Ghana exhibit conceptual difficulties in organic chemistry nomenclature. But research has shown that both REACT and 7E Instructional strategies, which are student-centered instructional methods, can improve students' academic performances better than the conventional teaching method. This is because students desist from rote memorization of concepts, and learn to apply the principles involved in the material. However, it appears only a single study has been conducted regarding their comparative study in Ghana and in the field of biology. In chemistry, no research work has been conducted regarding their comparative study especially in the Sekyere, Kumawu District. As a result, based on the literature reviewed, this study sought to investigate the comparative study of the 7E Instructional Model, REACT teaching strategies and conventional teaching method, on the academic performance of students in nomenclature of organic compounds.

CHAPTER THREE

METHODOLOGY

3.0 Overview

The research's study area is covered in this chapter. It also provides an explanation of the research design used for data collection. The study's population, sample, and sampling methods that were utilised to determine the study's sample size are also covered in this chapter. Additionally, a thorough explanation of the research instruments utilised to collect data is provided in this chapter. This chapter also covers the validity and reliability of the research instruments. The data collection process and the analysis of the collected data round up this chapter.

3.1 Study Area

Ghana's Ashanti Region comprises forty-three districts, one of which is Sekyere, Kumawu District. It was formerly a part of the bigger Sekyere East District, which was established by combining the former Sekyere District Council with other districts. Later, on November 1, 2007, a sizable section of the district was divided off to become the 1st Sekyere Afram Plains District, which was formally opened on February 29, 2008, with Kumawu serving as its capital. But on June 28, 2012, the district's Afram Plains portion was divided off to form the new Sekyere Afram Plains District, which has Kumawu as its capital town. The remaining portion of the district has since been formally renamed as Sekyere, Kumawu District. The district has 6 Senior High Schools. Two of them are private and four are public. There are also 23 private basic schools and 26 public basic schools (Sekyere, Kumawu District Assembly, 2021).

3.2 Research Paradigm

This study has its philosophical root from the positivist paradigm. The positivist paradigm, which is based on measurement and reason, holds that knowledge can be discovered by the objective, unbiased, and quantitative observation of behavior or action (Khaldi, 2017). One major tenet of positivism is that if something is not measurable in this manner, it cannot be certainly known (Alharahsheh & Pius, 2020). Therefore, positivists believe that the body of data gathered from observation, free of theory and value, is the source of scientific knowledge (Kivunja & Kuyini, 2017). This implies that anything that cannot be observed and, therefore, cannot be quantified or measured, has minimal significance. Thus, positivism and quantitative data collection techniques go hand in hand.

Adopting the positivist paradigm means that the scientific hypothetico-deductive model was used (Park *et al.*, 2020). Starting with theory from the literature, the hypothetico-deductive method, as Park *et al.* (2020) explain, builds testable hypotheses, designs an experiment by operationalizing variables (i.e., determining which variables to manipulate and measure), and then conducts an empirical study based on experimentation. In the end, the results of a study like this are applied to theory and literature, which completes the cycle theory → hypothesis → operationalizing variables → experimentation → theory. This study thus aligns with the principles of the positivist paradigm by adopting only quantitative research procedures to collect and analyse data in order to answer the research questions.

3.3 Research Design

This study adopted the quantitative research design. Quantitative research designs are often used to look at causal relationships, but they can also be used to look at relationships or relationship between variables (Bostley, 2019). Quantitative research designs include “true” or randomized experimental design, quasi-experimental design, descriptive designs, exploratory designs, survey design, explanatory designs, and correlational design (Creswell, 2012). In this study, the quasi-experimental design was employed. Specifically, a two experimental group and one control group pretest/posttest design was used. This is because, the sample were divided into three instructional groups where the experimental groups were instructed using REACT teaching strategies and 7E Instructional model and the control group instructed using the conventional teaching method. The main independent variables were REACT teaching strategies and 7E Instructional model. However, the dependent variable was students’ performances in organic chemistry nomenclature.

3.4 Population

The target population for this study included all SHS 3 Chemistry students in Sekyere, Kumawu District in the Ashanti Region, Ghana. SHS 3 Chemistry students were selected because Organic Chemistry is studied in SHS 3 according to the SHS syllabus.

3.5 Sample and Sampling Procedure

Three public SHSs in the Sekyere, Kumawu District who offered elective Chemistry were selected using simple random sampling. One intact SHS 3 Chemistry class from each selected school was also selected randomly. This was done since there were more than one intact Chemistry class in each selected school. Afterwards, the three intact classes selected were assigned randomly to experimental and control groups. The experimental groups were subjected to REACT teaching strategies and 7E Instructional Model, while the control group was subjected to the conventional teaching method. In all, one hundred and forty-seven (147) SHS 3 Chemistry students participated in the study, with the REACT group consisting of 50 SHS 3 students and the 7E group consisting of 49 SHS 3 students, while the control group consisted of 48 SHS 3 students. To control for interaction effect, each intact class was selected from a different town.

3.6 Data Collection Instrument

The main instrument used to collect data in this study was Organic Chemistry Nomenclature Concept Test (OCNCT) which was self-designed and was used as both pretest and posttest.

3.7 Organic Compound Nomenclature Concept Test (OCNCT)

The OCNCT was also prepared by the researcher. The OCNCT contained twenty (20) multiple choice items and two-essay type items related to the nomenclature of organic compounds which were considered in the study (see Appendix A). Multiple-choice and essay test items were used in order to minimize the weaknesses in each format. Each multiple-choice item contained lettered option A to D, where participants were to select the correct answer to the item. Therefore, any wrong answer selected by participant was scored zero (0), while a correct answer was scored one (1). Also, four essay type items were added to the multiple-choice items to cater for the inadequacies in the multiple-choice items. As a result, students were given the freedom to provide a range of answers where their answers were scored polytomously.

3.8 Validity of Instrument

The validity of the OCNCT was determined by inviting two experts in science education from Akenten Appiah-Menka University of Skills Training and Entrepreneurial Development (AAMUSTED), as well as two Chemistry teachers who teach Chemistry at SHS for their comments and suggestion. The experts were invited to determine the appropriateness of the items on the OCNCT in measuring students' academic performance in nomenclature of organic compounds.

3.9 Pilot Testing of Instruments

The pilot testing of the OCNCT was conducted in a Senior High School in the Sekyere, Kumawu District, using fifty-six (56) SHS 3 students.

3.10 Reliability of Instrument

Cronbach's alpha, and the inter-rater reliability method, thus Kappa measure of agreement was used to assess the reliability of the OCNCT. Specifically, Cronbach alpha was used to determine the internal consistency of the multiple-choice items while the Kappa measure of agreement was used to determine the internal consistency of the essay-type items.

3.10.1 Internal Consistency of Multiple-Choice Items of OCNCT

The scores of the multiple-choice section from the pilot study of the OCNCT was computed and the reliability, thus internal consistency of the scores, using Cronbach alpha was determined. The results are presented in Table 3.1.

Table 3.1: Internal Consistency of Multiple-Choice Section of OCNCT

Cronbach's Alpha	N of Items
0.826	20

As presented in Table 3.1, the Cronbach alpha value, which measured the internal consistency of the scores was 0.826. This value indicates a preferrable internal consistency of the scores according to Pallant (2011). This means that the internal consistency of multiple-choice section was reliable, and that the Cronbach Alpha value was high for the items to be used.

3.10.2 Internal Consistency of Essay-type Section of OCNCT

The scores of the essay-type section from the pilot study of the OCCNT was computed and the reliability, thus internal consistency of the scores, using Kappa measure of agreement, was determined. The results are presented in Table 3.2.

Table 3.2: Results of Kappa Measure of Agreement of Essay-type Items of OCNCT

		Value	Asymptotic Standard Error[a]	Approximate T[b]	Approximate Significance
Measure of Agreement	Kappa	.771	.082	33.556	.000
N of Valid Cases		56			

The internal consistency of the scores of the essay-type items from the pilot study was also determined using Kappa's measure of agreement. Mchugh (2012) presents a range for interpreting Kappa values, and according to Mchugh (2012) values ≤ 0 indicate no agreement and 0.01–0.20 as none to slight, 0.21–0.40 as fair, 0.41–0.60 as moderate, 0.61–0.80 as substantial, and 0.81–1.00 as almost perfect agreement. Therefore, a

Kappa value of 0.771 as seen in Table 1 indicates a substantial agreement. Therefore, the OCCNT was deemed reliable to be used for the pretest and posttest.

3.11 Data Collection Procedure

Quantitative data was collected in this study, and the data collection procedure was done in three stages.

3.11.1 Pre-intervention Stage

Formal permission was sought from the head teachers of the three schools selected for the study. The Chemistry teachers in these schools were also informed. Assistant headmaster of academics, teachers, and students from the sampled schools were informed of the advantages and applications of the study's findings, and they were reassured of the confidentiality of the findings and the data submitted by the students. After permission was given by various authorities to begin, simple random sampling was done to select one intact class from each school and also to categorise the classes into experimental and comparison groups. For confidentiality and data entry purposes, the experimental schools were identified as GROUP 1 (taught using REACT teaching strategies), and GROUP 2 (taught using 7E Instructional model), while comparison school were identified as GROUP 3 (taught using the conventional teaching method).

The sampled schools were then visited to begin the pretest. In order to ensure that students were prepared for the pretest, students were informed one week prior to the conduction of the pretest. The purpose of the pretest was to make sure that all participants had approximately equal entry behaviour characteristics before the introduction of the intervention. With the assistance of Chemistry teachers from the sampled schools, the researcher administered the pretest. During the administration of the pretest, students from all groups were given a period of 60 minutes to answer the test items.

3.11.2 Intervention Stage

The second phase of data collecting, the intervention stage, started after the pretest was successfully completed. To account for teacher differences, the researcher at this stage taught the subject matter in all the three (3) sampled schools. The intervention stage, which lasted for a period of four (4) weeks, involved teaching the same material to both experimental and comparison groups, but different treatments, where the experimental groups was exposed to REACT teaching strategies and 7E Instructional model, while the comparison group was exposed to the Conventional teaching method. Table 3.3 presents the activities students taught using REACT teaching strategies were exposed to.

Table 3.3: Instructional Activities used in REACT Group

Stage	Activity
Relating	Discussion of organic compounds found in common household items.
Experiencing	Provision of hands-on experiences through virtual simulations or interactive software to help students experience the process of naming organic compounds.
Applying	Presentation of a series of organic compounds and guiding students in applying nomenclature rules.
Cooperating	Organizations of group activities where students collaborated to solve nomenclature questions.
Transferring	Students were challenged to name compounds in the context of a hypothetical research project.

Relating

This stage involved relating the nomenclature of organic compounds to students' prior knowledge of chemical bonding. Discussion of organic compounds found in common household items. For example, relating the structure and nomenclature of ethanol (commonly found in alcoholic beverages) to the chemical formula C_2H_5OH. Again, here, the nomenclature rules were related to real-world examples, making the content relatable and interesting. Lastly, emphasis was made on how understanding nomenclature allows chemists to communicate precisely about the composition of substances we encounter daily.

Experiencing

This stage was characterized by the provision of hands-on experiences to help students experience the process of naming organic compounds, through the incorporation of virtual simulations or interactive software that allowed students to explore and practice naming compounds in a 3D space.

Applying

This stage was also marked by the presentation of a series of organic compounds and guiding students in applying nomenclature rules. For instance, asking them to name compounds like butanol, dimethyl ether, or hexanoic acid. A variety of functional groups and structural complexities were included to challenge students. Also, there was inclusion of real-life scenarios where students had to name compounds commonly found in household products or pharmaceuticals, thereby reinforcing the practical relevance of the skill.

Cooperating

At this stage there were organizations of group activities where students collaborated to solve nomenclature questions. Each group was assigned a set of organic compounds with varying complexities, where group members were encouraged to discuss and share strategies for applying nomenclature rules.

Transferring

At this stage, there were presentations of scenarios where students needed to apply their nomenclature skills to analyze and interpret information. For example, students were challenged to name compounds in the context of a hypothetical research project.

Students taught using 7E Instructional Model were also exposed to different activities using the 7E Instructional Model as presented in Table 3.4.

Table 3.4: Instructional Activities used in 7E Instructional Model Group

Stage	Activity
Elicitation	showing an image of a common organic compound or a short video clip highlighting the importance of organic compounds in daily life.
Engagement	Relating the lesson to students' prior knowledge of chemical bonding and real-world applications.
Exploration	Students were instructed to explore molecular models of simple organic compounds, identify functional groups, and discuss any patterns or similarities they observe. The teacher assisted the students at this stage to provide clear examples of how to name simple organic compounds using IUPAC rules.
Explanation	Students made short presentations to explain how the rules are used to name organic compound with different functional groups.
Elaboration	Students were provided with more complex examples of organic compounds.
Evaluation	Assessment of lesson objectives through formative assessments, such as a short exercises or group discussion.
Extension	Students were assigned projects or research tasks that required them to apply their knowledge of nomenclature in real-life scenarios.

Elicitation

The lesson began by showing an image of a common organic compound or a short video clip highlighting the importance of organic compounds in daily life. Also, open-ended questions were asked to elicit students' prior knowledge, such as: "What comes to mind when you hear the term 'organic compounds'?" "Can you think of any products or substances around you that might contain organic compounds?"

Engagement

At this stage the teacher related the lesson to students' prior knowledge of chemical bonding and real-world applications, explaining how naming conventions are crucial for communication in the scientific community and industries.

Exploration

Molecular models or structural formulas of simple organic compounds were distributed to small groups, where students were instructed to explore the compounds, identify functional groups, and discuss any patterns or similarities they observe. After students had formed groups, IUPAC nomenclature rules for organic compounds were introduced. The teacher assisted the students at this stage to provide clear examples of how to name simple organic compounds (e.g., alkanes, alkenes, alkynes) following these rules, using visuals and step-by-step explanations to make the process more accessible.

Explanation

After exploring how to apply the rules to name simple organic compounds, each group made a short presentation to explain how the rules are used to name organic compound with different functional groups.

Elaboration

Students were provided with more complex examples of organic compounds, including those with substituents, functional groups, and branching.

Evaluation

students' understandings were assessed through formative assessments, such as a short exercises or group discussion.

Extension

Students were assigned projects or research tasks that required them to apply their knowledge of nomenclature in real-life scenarios in fields like medicine, agriculture, or environmental science.

Activities for Control Group

The control group was exposed to the conventional teaching method, which was characterized by lecture or teacher-centred activities during the teaching and learning of organic compounds. The following highlights how the conventional teaching method was implemented in the control group.

Table 3.5: Treatment Activities of Control Group

STAGE	ACTIVITY
Stage 1 Introduction	The researcher presents the lesson to the students
Stage 2 Development	The researcher explains key points and write notes for students to copy
Stage 3 Application	The researcher gives students in-class examples and questions to solve
Stage 4 Evaluation	Using both formative and summative assessment techniques to determine the achievement of lesson objectives.

Introduction

The teacher stimulated students' relevant previous knowledge (RPK) of nomenclature of organic compound before beginning the course. This was done by asking students few questions relating to organic compounds which students had experienced in real life and through the studies of naming of inorganic compounds which is a pre-requisite concept to the understanding of organic compounds. Based on the responses from the students, the teacher introduced the lesson.

Development

While students listened, the teacher explained to the students the various rules in naming organic compounds using mental imaginations, as well as noting key ideas and explanations on the board. Students were then asked to write notes from the board into their note books.

Application

Teacher used real-life examples to link what had been taught to students in order to provide better understanding of concepts to students.

Evaluation

The teacher assessed the students by asking brief questions and allowing them to respond with replies. The students were given exercises and assignments to complete in their books for marking

3.11.3 Post-Intervention Stage

After the intervention stage, students were given one week to revise their notes, after which the posttest was conducted. The conduction of the posttest was also done by the researcher with the assistance of Chemistry teachers from the various schools. Students from the three groups were given 40 minutes to answer the posttest items.

3.12 Data Analyses Procedure

The data from the research instrument were analysed quantitatively. The scores from the OCNCT were analysed using Statistical Package for Social Science (SPSS). Descriptive and Inferential statistics were used to answer the research questions, using the accepted level of significance ($p<0.05$). Descriptively, mean, standard deviation, and effect size were used as part of inferential statistics (independent sample t-test), to answer all the research questions. Independent sample t-test was employed in answering research questions 1 and 2 because there was no significant difference in the pretest scores between all groups. Research question 3 was however answered using one-way analysis of variance on the posttest scores since three groups were compared.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.0 Overview

This chapter entails the distribution of the participants, results of the study, as well as the discussion of the results. The results are presented based on the research questions. The data were analysed in terms of descriptive and inferential statistics. The results are presented based on the research questions.

4.1 Distribution of Participants

This quasi-experimental study employed 147 participants from three randomly selected intact classes in three different locations. The intact classes were randomly categorized into experimental and control groups, with each group exposed to different treatment. The distribution of the participants according to their groups and gender are presented in Table 4.1

Table 4.1: Distribution of Participants

Group	Frequency	Percentage
REACT	50	34.014%
7E	49	33.333%
CONVENTIONAL	48	32.653%

Table 4.1 shows that, among these 147 Chemistry students, 50 (34.014%) belonged to REACT group (taught using REACT teaching strategies), 49 (33.333%) belonged to 7E group (taught using 7E Instructional model), while 48 (32.653%) belonged the Conventional group (taught using conventional teaching method).

4.2 Normality of Data

In this study, since parametric tests were conducted on the data collected (pretest and posttest scores), it was appropriate that, as one of the assumptions of parametric tests, normality tests be conducted on the pretest and posttest scores for all groups, in order to determine whether the data collected were suitable for parametric analyses. In conducting normality tests, the Shapiro-Wilk's test was employed. According to Hernandez (2021), the Shapiro-Wilk test of normality has more statistical power. However, normality test was conducted on the null hypothesis that, the data was normally distributed (Hernandez, 2021), which means the null hypothesis is rejected if the p-value is less than 0.05. The results of the Shapiro-Wilk's test of normality on the pretest and posttest scores for all groups are presented in Table 4.2

Table 4.2: Results of Shapiro-Wilk's Test of Normality on Pretest and Posttest Scores for All Groups

			Shapiro-Wilk	
	GROUP	**W**	**df**	**p**
Pretest Scores	REACT	.955	50	.055
	7E	.945	49	.063
	Conventional	.968	48	.213
Posttest Scores	REACT	.966	50	.160
	7E	.968	49	.195
	Conventional	.962	48	.121

Table 4.2 reveals that, the Shapiro-Wilk test of normality for pretest scores of REACT group, 7E group, and Conventional group produced non-significant values of 0.955 (p-0.055), 0.945(p-0.063), and 0.968(p-0.213) respectively. Similarly, the Shapiro-Wilk test of normality for posttest scores of REACT group, 7E group, and Conventional group produced non-significant values of 0.966(p=0.160), 0.968(p=0.195), and 0.962(p=0.121) respectively. As a result, the null hypothesis was accepted, which

means that the pretest and posttest scores did not deviate from normality, hence parametric tests were used for analyses.

4.3 Entry Characteristics of Participants

In this study participants were not randomly assigned into experimental and control groups due to the design employed. As a result, students' entry characteristics (academic performance) were determined prior to the intervention. This was to determine whether all groups performed at similar levels. In view of that, a one-way between groups analysis of variance was conducted on the pretest scores of all groups. However, a one-way analysis of variance operates on an assumption called the "assumption of homogeneity of variances". That is, the variances in the pretest scores between all groups are equal (Pallant, 2011). This assumption was tested using Levene's test and the results are presented in Table 4.3.

Table 4.3: Results of Test of Homogeneity of Variances

	Levene Statistic F	df1	df2	p
Pretest	.408	2	144	.666

From Table 4.3, Levene's test, F, was not significant (F=0.408, p=0.666). Therefore, the null hypothesis was accepted, which means that the variances in pretest scores of all groups were equal. Therefore, the one-way analysis of variance was conducted and the results are presented in Table 4.3.

Table 4.4: One-Way Between Groups Analysis of Variance on Pretest Scores for All Groups

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	5.760	2	2.880	.809	.447
Within Groups	512.906	144	3.562		
Total	518.667	146			

As revealed in Table 4.4, there was no significant difference in pretest scores between the 7E Instructional Model, REACT and Conventional groups ($F_{(2,144)}$, p=0.447). This indicates that SHS students assigned to both experimental and control groups were at similar levels of performance before the intervention.

4.3 Results of the Study

4.3.1 Results of Research Question 1

What is the difference in performance between students taught nomenclature of organic compounds using the 7E instructional Model and conventional teaching method?

To answer this research question, an independent sample t-test was conducted on the pretest scores of the 7E instructional model group and conventional group to determine whether there was significant difference between both groups in which would inform the statistical tool to use on the posttest scores. The results are presented in Table 4.4.

Table 4.5: Independent Sample t-test on Pretest Scores for 7E Instructional Model Group and Conventional Group

	Gender	N	Mean	SD	t	df	*p*
Equal variances assumed	7E	49	9.90	1.771	1.164	95	.247
	Conventional	48	9.46	1.946			

As shown in Table 4.5, the pre-test scores between 7E Instructional Model group (M=9.90, SD=1.771) and conventional group (M=9.46, SD=1.946; t (95) =1.164, p-0.247>0.005) showed no statistically significant difference. The difference in academic performance between students taught nomenclature of organic compounds using the 7E instructional model and those taught through the conventional approach was therefore determined using an independent samples t-test on the posttest scores. Preliminary checks were conducted to ensure that there was no violation of the assumptions of normality, linearity, homogeneity of variances. The result of independent sample t-test on the posttest scores of 7E and conventional approach is shown in table 4.6.

Table 4.6: Results of Independent Samples t-test on Posttest Scores of 7E Instructional Approach and the Conventional Approach

Group	N	Mean	SD	t	df	p	Eta Squared
7E	49	23.93	2.296	12.949	95	.000	0.641
Conventional	48	18.15	2.093				

From Table 4.6, there was a significant difference in posttest scores for students taught using 7E Instructional approach (M = 23.93, SD = 2.296) and students taught using the conventional teaching method (M =18.15, SD=2.093; t(95) = 12.949, p =.000). Since there was a significant difference, the magnitude of the difference was determined using eta squared statistic (see Appendix B) as seen from Table 4.6. From Table 4.6, it can be observed the eta squared statistic produced a value of 0.641, indicating a moderate effect size in favor of the 7E group (Pallant, 2011).

4.3.2 Results of Research Question 2

What is the difference in performance between students taught nomenclature of organic compounds using the REACT instructional strategy and those taught through the conventional approach?

To answer this research question, an independent sample t-test was conducted on the pretest scores of the REACT group and conventional group to determine whether there was significant difference between both groups in which would inform the statistical tool to use on the posttest scores. The results are presented in Table 4.7.

Table 4.7: Independent Sample t-test on Pretest Scores for REACT Group and Conventional Group

Gender	N	Mean	SD	t	df	p
REACT	50	9.50	1.940	0.106	96	.916
Conventional	48	9.46	1.946			

As shown in Table 4.7, the pre-test scores between REACT group (M=9.50, SD=1.940) and conventional group (M=9.46, SD=1.946; t (95) =0.106, p=0.916>0.005) showed no statistically significant difference. The difference in academic performance between students taught nomenclature of organic compounds using the REACT instructional strategies and those taught through the conventional approach was therefore determined using an independent samples t-test on the posttest scores. The results of the independent samples t-test on the posttest scores of REACT group and conventional group are presented in Table 4.7.

Table 4.7: Results of Independent Samples t-test on Posttest Scores of REACT and Conventional Groups

	Group	N	Mean	SD	t	df	*p*	Eta Squared
Equal variances assumed	REACT	50	24.43	2.335	14	96	.000	0.669
	Conventional	48	18.15	2.093				

As shown in Table 4.7, there was a significant difference in posttest scores for students taught using REACT Instructional strategies (M = 24.43, SD = 2.335) and students taught using the conventional teaching method (M = 18.15, SD = 2.093; t(96) = 14.000, p -.000). Since there was a significant difference, the magnitude of the difference was therefore determined using eta squared statistic (see Appendix B) as seen from Table 4.8. From Table 4.7, it can be observed the eta squared statistic produced a value of 0.669, indicating a moderate effect size in favor of the REACT group (Pallant, 2011).

4.3.3 Results of Research Question 3

What is the difference in performance between students taught nomenclature of organic compounds using the 7E instructional model, the REACT instructional strategy and the conventional approach?

To answer this research question, a one-way between groups analysis of variance was conducted on the posttest scores of the 7E, REACT and conventional groups since there was no significant difference in the pretest scores as shown in Table 4.9. The results are presented in Table 4.9.

Table 4.9: One-Way ANOVA on Posttest Scores for REACT 7E, and Conventional Groups

Group	Sum of Squares	df	Mean Square	F	*p*
Between Groups	696.107	2	348.053	69.011	.000
Within Groups	726.260	144	5.043		
Total	1422.367	146			

As shown in Table 4.9, there was a statistically significant difference in posttest scores between all the three groups ($F_{(2,144)} = 69.011$, p=0.000<0.05). Since there was a significant difference, post-hoc comparisons using the Tukey HSD test was conducted to determine between which groups the significant difference lay. The results of the post-hoc test are presented in Table 4.10.

Table 4.10: Tukey HSD Post-hoc Analysis on Posttest Scores for All Groups

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.
REACT Group	7E Group	0.500^{*}	.451	.127
	Conventional	5.194^{*}	.454	.000
7E Group	Conventional	1.609^{*}	.456	.002

* *p<0.05*

As indicated in Table 4.10, post-hoc comparisons using the Tukey HSD test indicated that the mean difference between REACT group and 7E group was not statistically significant (mean difference = 0.500, p=0.127). However, the mean difference between the REACT group and the conventional group was statistically significant (mean difference = 5.194, p=0.000), as well as the mean difference between the 7E group and the conventional group was statistically significant (mean difference = 1.609, p = 0.002).

4.4 Discussion of Results

4.4.1 Discussion of Results of Research Question 1

Research question 1 sought to determine the difference in academic performance between students taught nomenclature of organic compounds using the 7E instructional model and those taught using the conventional approach. The research question was thus answered using an independent sample t-test on the posttest scores of students taught using 7E Instructional model and the conventional teaching method. It was revealed in this study that there was a significant difference in posttest scores for students taught using 7E Instructional model ($M = 23.93$, $SD = 2.296$) and students taught using the conventional teaching method ($M = 18.15$, $SD = 2.093$; $t(95) = 12.946$, $p = .000$), with an effect size of 0.641 which indicates that the magnitude of the difference was moderate. This means that the 7E Instructional Model was more effective than the conventional teaching method. This finding therefore was consistent with the findings of Marfilinda *et al.* (2020), Shuaibu *et al.* (2021), Juliana *et al.* (2021), and Gyampoh *et al.* (2021) who found the 7E Instructional model to be more effective than the conventional teaching method. The effectiveness of 7E Instructional model is because, according to Balta and Sarac (2016) active learning is a key component of the 7E concept. It motivates students to actively participate in their own learning by including them in a variety of activities. As Bybee *et al.* (2006) affirmed, going through all the stages in the 7E Instructional Model make connections between past and present learning experiences, expose prior conceptions, and organize students' thinking toward the learning outcomes of current activities. Improved motivation and subject-matter comprehension can result from active participation (Lai *et al.*, 2018). In this study, the 7E Instructional Model's emphasis on assessing prior knowledge, active exploration, and real-world application might have allowed students to develop a deeper understanding of naming rules and their significance. By engaging students in hands-on activities, encouraging critical thinking, and connecting learning to practical applications, the 7E model equipped students with the skills and knowledge needed for success in mastering organic compound nomenclature. In contrast to conventional teaching methods, which might have encouraged rote memorization and passive learning, the 7E Instructional Model promotes active learning, critical thinking, and real-world application.

7E addresses students' individual needs, misconceptions, and learning styles more effectively, thereby enhancing engagement, understanding, retention, and application of knowledge in the field of organic compound nomenclature. In the conventional classroom, students often received information through lectures, readings, and demonstrations without active engagement in the learning process. This passive approach, according to Sawant and Rizvi (2015), can hinder deep understanding and retention as students may struggle to connect abstract concepts to real-world applications or experiences. Additionally, the lack of hands-on learning opportunities in the conventional method could be a significant drawback. Organic chemistry nomenclature involves understanding complex rules and applying them to diverse molecular structures (Adu-Gyamfi *et al.*, 2017). Without the chance to physically manipulate models or engage in interactive exercises, students may struggle to visualize and internalize these concepts fully. This limitation can result in a surface-level understanding that may not translate well to practical problem-solving or higher-order thinking tasks. Another factor which might have contributed to the conventional teaching method's inefficacy is the absence of immediate feedback and opportunities for reflection. In the absence of regular assessments or interactive discussions, students may not receive timely guidance on their progress or misconceptions (McCallum & Milner, 2021). This lack of feedback can lead to misunderstandings persisting unchecked (Owen, 2016), ultimately hindering the development of a strong foundation in organic chemistry nomenclature. In contrast, the 7E instructional model's emphasis on continuous evaluation, explanation, and application allows for ongoing feedback loops that support deeper learning and concept mastery.

4.4.2 Discussion of Results of Research Question 2

Research question 2 also sought to determine the difference in academic performance between students taught nomenclature of organic compounds using the REACT instructional strategies and those taught using the conventional approach. Research question 2 was therefore answered using an independent samples t-test on the posttest scores of students taught using REACT instructional strategies and the conventional teaching method. It was revealed that there was a significant difference in posttest scores for students taught using REACT Instructional strategies ($M = 24.43$, $SD = 2.335$) and students taught using the conventional teaching method ($M = 18.15$, $SD = 2.093$; $t(96) = 14.000$, $p =.000$), with a moderate effect size of 0.669 in favor of REACT. This indicates that the REACT teaching strategies was more effective than the conventional teaching method. This finding is also in support of the findings of Balta and Sarac (2016), Quainoo *et al.* (2021), Bilgin *et al.* (2017), Akay and Kanadli (2021), and Günter (2018) who all revealed the effectiveness of REACT teaching method on students' academic performance than the conventional teaching method. The comprehensive approach of the REACT teaching strategies, encompassing relational connections, experiential learning, practical application, cooperative learning, and transferability of knowledge, proved highly effective in helping students not only understand but also apply and retain the nomenclature of organic compounds, surpassing the limitations of conventional teaching methods. For instance, according to Herlina and Ilmadi (2022) as well as Utami *et al.* (2016), the REACT strategy's active, immersive, and collaborative elements help increase students' interest and involvement in their education. Students are more inclined to put time and effort into their studies when they are motivated, and this can result in better achievement.

This findings was confirmed by Quainoo *et al.* (2021) who found in a semi-structured interview that, being exposed to REACT teaching strategy enhances students motivation to search for information on their own, and share this knowledge they have gained during the collaborative stage in the REACT classroom. By using REACT teaching strategies in this study, students were encouraged to establish connections between the naming rules and their prior knowledge or everyday experiences. This initial step helps create a solid foundation for learning (Wahyuni, 2013), by framing the nomenclature rules within familiar contexts, making them more accessible and relevant to students. By relating new information to what they already know, students are better prepared to grasp the significance and applicability of the naming conventions (Alanazi, 2016). Also, in using REACT teaching strategies, students were actively engaged in hands-on learning experiences that allowed them to interact with organic compounds directly. This experiential learning approach involved using molecular models, observing compound structures, and manipulating molecules to understand how naming rules are applied in practice. By engaging multiple senses and providing a tangible experience, students developed a deeper understanding of the relationships between molecular structures and their names. This immersive learning experience not only aids in comprehension but also fosters a sense of curiosity and exploration in students, driving their motivation to learn (Saif & Laszlo, 2020).

4.4.3 Discussion of Results of Research Question 3

Research question 3 also sought to determine the difference in academic performance between students taught nomenclature of organic compounds using 7E Instructional Model, REACT instructional strategies, and the conventional teaching method. Thus, a one-way between groups analysis of variance was used to answer this research question, and it was found that there was no significant difference in posttest scores for students taught using 7E Instructional model and students taught using REACT teaching strategies, while there was significant differences between students taught using 7E Instructional model and conventional teaching method, as well as a significant difference between students taught using REACT teaching strategies and conventional teaching method. This means that both REACT teaching strategies and the 7E Instructional Model equally enhances students' academic performances in Organic Chemistry. This finding also supported that of Quainoo (2019) who found the employment of both REACT teaching strategies and the 7E Instructional Model to enhance students' academic performance in genetics. This might be as a result of students actively participating in both the execution of both instructional strategies and their learning experiences in this classroom.

Munyaradzi (2013) argues that students are able to discover how to acquire independence, transferable skills, become independent learners, articulate their understanding, and lead their learning via inquiry as they work at their own speed. By approaching the curriculum with curiosity and practical application, students who are given the freedom to conduct their own learning are more likely to be engaged in the course material. The use of REACT teaching strategies and 7E Instructional model both emphasize on giving students the freedom to own the material they learn in the classroom through inquiry and collaboration. This then results in improving students' academic performances (Dole *et al.*, 2016).

The use of these models ensured a comprehensive learning experience that engaged students at multiple levels—cognitive, experiential, and collaborative. This holistic approach fostered a deeper understanding of organic chemistry nomenclature, equipping students with the skills and knowledge needed for success in this complex field. Ultimately, the integration of the 7E Instructional Model and REACT teaching strategies offered a synergistic approach that maximized learning outcomes and empowered students to excel in mastering the nomenclature of organic compounds.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.0 Overview

In this chapter, the summaries of the findings of the study have been highlighted. Conclusions, recommendations, and suggestions were also noted for further studies based on the findings.

5.1 Summary of Findings

The study investigated the effects of 7E instructional model, the REACT teaching strategy and conventional teaching method on Senior High School Chemistry students' academic performance in the nomenclature of organic compounds. After collecting and analysing data, it was found that there was a significant difference in performance between SHS 3 Chemistry students taught using 7E Instructional model and those taught using the conventional teaching method.

The study also revealed that, after the intervention, there was a significant difference in performance between SHS 3 Chemistry students taught using REACT teaching strategies and those taught using the conventional teaching method. Also, it was found that there was a significant difference in performance between the three instructional groups, thus REACT teaching group, 7E instructional group and conventional group. However, a post-hoc analysis revealed that while significant difference was found between the REAC instructional group and the conventional group, as well as between the 7E instructional group and the conventional group, no significant difference existed between REACT instructional group and 7E instructional group.

5.2 Conclusions

Based on the results of this study, it can be concluded that using REACT teaching strategies and the 7E Instructional Model in the Sekyere, Kumawu District was more effective in enhancing students' understanding in nomenclature of organic chemistry than the conventional teaching method. This can be explained by the fact that, both the 7E Instructional Model and REACT teaching strategies placed students at the center of the teaching and learning process, through the employment of diverse techniques and hands-on experiments, which made content real to them. This study therefore extends existing studies by providing evidence to support which student-centred instructional approach would be effective in the teaching and learning of nomenclature of organic compounds. However, this quantitative evidence does not provide a holistic understanding of the effectiveness of the two instructional approaches over the conventional teaching approach. Therefore, this evidence is limited to only the cognitive aspect of learning.

5.3 Recommendations

The findings of this study have led to the recommendations that:

1. Chemistry teachers in Sekyere, Kumawu District should employ REACT teaching strategies more than the conventional teaching method in the teaching and learning of nomenclature of organic compounds.
2. Chemistry teachers in Sekyere, Kumawu District should employ 7E Instructional Model more than the conventional teaching method during the teaching and learning of Alkenes which will improve students' understanding, thereby improving their performances.

3. Since both REACT teaching strategies and 7E Instructional Model enhanced students' performance in nomenclature of organic compounds, Chemistry teachers in Sekyere, Kumawu District are encouraged to equally consider the employment of both teaching approaches in their organic compounds nomenclature lessons.

5.4 Suggestion for Further Research

Based on the findings of this study it is suggested that more studies should be conducted on the effect of REACT teaching strategies and 7E Instructional Model in different geographical areas.

REFERENCES

Abanikannda, M. O. (2016). Influence of problem-based learning in chemistry on academic achievement of high school students in osun state, Nigeria. *International Journal of Education, Learning and Development*, *4*(3), 55-63

Abimbade, O., Akinyemi, A., Bello, L., & Olusegun, M. H. (2018). Comparative Effects of an Individualized Computer Based Instruction and a Modified Conventional Strategy on Students ' Academic Achievement in Organic Chemistry. *Journal of Positive Psychology and Counselling*, *2*(1), 1–19.

Adesoji, F. A., & Idika, M. I. (2015). Effects of 7E Learning Cycle Model and Case-Based Learning Strategy on Secondary School Students' Learning Outcomes in Chemistry. *Journal of the International Society for Teacher Education*, *19*(1), 7–17.

Adu-Gyamfi, K., & Asaki, I. A. (2023). Factors contributing to teachers' conceptual difficulties in teaching high school organic chemistry. *European Journal of Science and Mathematics Education*, *11*(1), 49–67. https://doi.org/10.30935/scimath/12433

Adu-Gyamfi, K., Ampiah, J. G., & Appiah, J. Y. (2017). Students' Difficulties in IUPAC Naming of Organic Compounds. *Journal of Science and Mathematics Education*, *6*(2), 77–106.

Ajayi, O. V. (2017). Relationship between Teachers' content knowledge , qualifications , experience and Students' achievement in Chemistry. *Scholarly Journal of Education*, *6*(1), 14–20.

Akay, C., & Kanadli, S. (2021). The Effect Of React Strategy On Achievement In Science Education: A Mixed Research Synthesis. *Journal of Baltic Science Education*, *20*(6), 868–881. https://doi.org/10.33225/jbse/21.20.868 869

Akpan, V. I., Igwe, U. A., Mpamah, I. B. I., & Okoro, C. O. (2020). Social Constructivism: Implications on Teaching and Learning. *British Journal of Education*, *8*(8), 49–56.

Al-taai, S. H. H. (2021). Teaching Methods: A Study Of Their Importance And Types In Educational Institutions. *Journal of Legal, Ethical and Regulatory Issues*, *24*(6), 1–14.

Alanazi, A. (2016). A Critical Review of Constructivist Theory and the Emergence of Constructionism. *American Research Journal of Humanities and Social Sciences*, *2*, 1–8.

Alharahsheh, H. H., & Pius, A. (2020). A Review of Key Paradigms: Positivism VS Interpretivism. *Global Academic Journal of Humanities and Social Science*, *2*(3), 39–43. https://doi.org/10.36348/gajhss.2020.v02i03.001

Aljohani, M. (2017). Principles of "Constructivism" in Foreign Language Teaching. *Journal of Literature and Art Studies*, *7*(1), 97–107. https://doi.org/10.17265/2159-5836/2017.01.013

Anim-Eduful, B., & Adu-Gyamfi, K. (2021). Functional Groups Detection: Do Chemistry Teachers Demonstrate Conceptual Difficulties in Teaching? *Global Journal of Human-Social Science*, *21*(February 2022), 47–60. https://doi.org/10.34257/gjhssgvol21is7pg47

Anim-Eduful, B., & Adu-Gyamfi, K. (2022). Factors Influencing High School Chemistry Teachers' and Students' Teaching and Learning of Organic Qualitative Analysis: a Qualitative Study. *European Journal of Education Studies, 9*(7), 194–219. https://doi.org/10.46827/ejes.v9i7.4378

Appiah-Twumasi, E. (2020). An Investigation into the Selection of Teaching Methods and Factors Influencing the Selection: A Case of Science Teachers of Berekum Municipality, Ghana. *International Journal of Innovative Research and Development*, *9*(12), 67–74. https://doi.org/10.24940/ijird/2020/v9/i12/dec20050

Bada, S. O. (2015). Constructivism: A Paradigm for Teaching and Learning. *Arts and Social Sciences Journal*, *5*(6), 66–70. https://doi.org/10.4172/2151-6200.1000200

Balta, N., & Sarac, H. (2016). The Effect of 7E Learning Cycle on Learning in Science Teaching: A meta-Analysis Study. *European Journal of Educational Research*, *5*(2), 61–72. https://doi.org/10.12973/eu-jer.5.2.61

Bekenova, A., & Nygatayeva, N. (2017). Transition from a Teacher-Centered to a Learner-Centered approach in Kazkhstani Education. *Bulletin of Science of Seifullin Kazakh Agro Technical University (Interdisciplinary), 1*(92), 106–111.

Bilgin, A. K., Yürükel, F. N., & Yiğit, N. (2017). The effect of a developed REACT strategy on the conceptual understanding of students: "Particulate nature of matter." *Journal of Turkish Science Education, 14*(2), 65–81. https://doi.org/10.12973/tused.10199a

Boonk, L., Gijselaers, H. J., Ritzen, H., & Brand-Gruwel, S. (2018). A review of the relationship between parental involvement indicators and academic achievement. *Educational research review*, *24*, 10-30.

Bostley, M. A. (2019). Basics of research design: A guide to selecting appropriate research design. *International Journal of Contemporary Applied Researches, Vol. 6, No*(5), 76–89. https://www.researchgate.net/publication/342354309_Basics_of_Research_Design_A_Guide_to_selecting_appropriate_research_design.

Bozkurt, G. (2017). Social constructivism: Does it succeed in reconciling individual cognition with social teaching and learning practices in mathematics? *Journal of Education and Practice*, *8*(3), 210–218. www.iiste.org

Bülbül, Y. (2010). *Effects of 7E Learning Cycle Model Accompanied With Computer Animations On Understanding Of Diffusion And Osmosis Concepts*. Middle East Tehnical University.

Bybee, R. W., Taylor, J. A., Gardner, A., Van, P., Powell, J. C., Westbrook, A., Landes, N., Spiegel, S., Stuhlsatz, M. M., Ellis, A., Thomas, H., Bloom, M., Moran, R., Getty, S., & Knapp, N. (2006). The BSCS 5E Instructional Model : Origins and Effectiveness by 5415 Mark Dabling Boulevard. *Science*, *June*.

Cathcart, A., Laundon, M., & Greer, D. A. (2020). Teaching Philosophy Statements. *Journal OfManagement Education*, *44*(5), 577–587. https://doi.org/10.1177/1052562920942289

Çelikler, D., Yenikalaycı, N., & Aksan, Z. (2017). Teaching the Inorganic Compounds with the Application of 2-d Code. *Journal of Education and Practice*, *8*(27), 148–152.

Ceylan, V. K., & Kesici, A. E. (2017). Effect of blended learning to academic achievement. *Journal of Human Sciences, 14*(1), 308-320

CORD. (2016). *REACTing to Learn : Student Engagement Strategies in Contextual Teaching and Learning*.

Crawford, M. L. (2001). *Teaching Contextually Research, Rationale, and Techniques for Improving Student Motivation and Achievement in Mathematics and Science*. CCI Publishing, Inc.

Creswell, J. W. (2012). Educational Research: Planning, Conducting, and Evaluating Quantitative and Qualitative Research. In *Pearson Education, Inc.* (4th ed.). Pearson Education, Inc.

Davis, G. (2016). *Investigation of most difficult Organic Chemistry Topics for Senior Secondary School students and teachers in the Central Region of Ghana*. 1–23.

Dole, S., Bloom, L., & Kowalske, K. (2016). Transforming Pedagogy : Changing Perspectives from Teacher-Centered to Learner-Centered The Interdisciplinary Journal of Problem-based Learning Transforming Pedagogy : Changing Perspectives from Teacher-Centered to Learner-Centered. *Interdisciplinary Journal of Problem-Based Learning*, *10*(1). https://doi.org/https://doi.org/10.7771/1541-5015.1538

Donkoh, S. (2017a). Very difficult senior high school organic chemistry topics: students and teachers perception. *International Journal of Creative Research Thoughts*, *5*(4), 2746–2752.

Donkoh, S. (2017b). What Students Say About Senior High School Organic Chemistry. *International Journal of Environmental & Science Education*, *12*(10), 2139–2152. http://creativecommons.org/licenses/by/4.0/

Dwyer, A. O., & Childs, P. E. (2017). Who says Organic Chemistry is Difficult? Exploring Perspectives and Perceptions. *EURASIA Journal of Mathematics Science and Technology Education*, *13*(7), 3599–3620. https://doi.org/10.12973/eurasia.2017.00748a

Eisenkraft, A. (2003). *Expanding the 5E Model*. *70*(6), 57–59.

Felder, R., & Brent, R. (2017). Learner-Centered Teaching : How and Why *. *Learning Abstracts*, *20*(5).

Golder, J. (2018). Constructivism : a Paradigm for. *International Journal of Research and Analytical Reviews*, *5*(3), 678–686.

Günter, T. (2018). The effect of the REACT strategy on students ' achievements with regard to solubility equilibrium : using chemistry in contexts. *Journal of Chemistry Education Research and Practice*.https://doi.org/10.1039/c8rp00087e

Gyampoh, O. A., Aido, B., Nyagbblosmase, G. A., Kofi, M., & Amoako, S. K. (2021). Investigating the effect of 7E Learning Cycle Model of Inquiry-Based Instruction on Students' Achievement in Science. *Academia.Edu*, *10*(5), 39–44. https://doi.org/10.9790/7388-1005013944

Hartshorn, R. M., & Yerin, A. (2019). The Past, Present, and Future in the Nomenclature and Structure Representation of Inorganic Compounds. *Dalton Transactions*, *48*(26), 9422–9430. https://doi.org/10.1039/c9dt00352e

Herlina, E., & Ilmadi, I. (2022). The Implementation of REACT Strategy in Training Students' Higher Order Thinking Skills (HOTS). *Ta'dib*, *25*(1), 47. https://doi.org/10.31958/jt.v25i1.5049

Hernandez, H. (2021). Testing for Normality: What is the Best Method? *ForsChem Research*, *6*(5), 1–38. https://doi.org/10.13140/RG.2.2.13926.14406

Jack, G. U. (2017). The Effect of Learning Cycle Constructivist-Based Approach on Students’ Academic Achievement and Attitude towards Chemistry in Secondary Schools in North-Eastern Part of Nigeria. *Educational Research and Reviews*, *12*(7), 456–466. https://doi.org/10.5897/ERR2016.3095

Juliana, C., Dinah, S., & Kabesa, S. (2021). Effect of 7E Learning Cycle Model on Students’ Academic Achievement in Biology in Secondary Schools in Chesumei Subcounty, Kenya. *African Journal of Education, Science and Technology*, *6*(3), 295–305.

Juuti, K., Lavonen, J., Uitto, A., Byman, R., & Meisalo, V. (2010). Science Teaching Methods Preferred by Grade 9 Students in Finland. *International Journal of Science and Mathematics Education*, *8*(4), 611–632. https://doi.org/10.1007/s10763-009-9177-8

Kalpana, T. (2014). A Constructivist Perspective on Teaching and Learning: A Conceptual Framework. *International Research Journal of Social Sciences*, *3*(1), 27–29. http://www.isca.in/IJSS/Archive/v3/i1/6.ISCA-IRJSS-2013-186.pdf

Kaya, S., & Gül, Ş. (2021). the Effect of React Strategy-Based Instruction on 11Th Grade Students’ Attitudes and Motivations. *European Journal of Education Studies*, *8*(3), 24–26. https://doi.org/10.46827/ejes.v8i3.3609

Khaldi, K. (2017). Quantitative, Qualitative or Mixed Research: Which Research Paradigm to Use? *Journal of Educational and Social Research*, *7*(2), 15–24. https://doi.org/10.5901/jesr.2017.v7n2p15

Kivunja, C., & Kuyini, A. B. (2017). Understanding and Applying Research Paradigms in Educational Contexts. *International Journal of Higher Education*, *6*(5), 26. https://doi.org/10.5430/ijhe.v6n5p26

Lai, H. M., Hsiao, Y. L., & Hsieh, P. J. (2018). The role of motivation, ability, and opportunity in university teachers' continuance use intention for flipped teaching. *Computers and Education*, *124*(May), 37–50. https://doi.org/10.1016/j.compedu.2018.05.013

Lak, M., Soleimani, H., & Parvaneh, F. (2017). The Effect of Teacher-Centeredness Method vs. Learner-Centeredness Method on Reading Comprehension among Iranian EFL Learners. *Journal of Advances in English Language Teaching*, *5*(1), 1–10. www.european-science.com/http://www.european-science.com/jaelt

Marfilinda, R., Rossa, R., Jendriadi, J., & Apfani, S. (2020). The Effect of 7E Learning Cycle Model toward Students' Learning Outcome of Basic Science Concept. *Journal of Teaching and Learning in Elementary Education (Jtlee)*, *3*(1), 77–87. https://doi.org/10.33578/jtlee.v3i1.7826

Marlan. (2017). The "REACT" Strategy Application in the Study of Mathematics. *Asian Journal of Natural & Applied Sciences*, *6*(4), 123–127.

Mayeem, B. P., Naa, A. M., & Adjei, A. (2018). Enhancing Senior High School Students Understanding of Chemical Formulae and Nomenclature of Inorganic Compounds by the Use of Improvised Conceptual Models. *Journal of Education and Practice*, *9*(6), 22–45.

McCallum, S., & Milner, M. M. (2021). The effectiveness of formative assessment: student views and staff reflections. *Assessment and Evaluation in Higher Education*, *46*(1), 1–16. https://doi.org/10.1080/02602938.2020.1754761

Mchugh, M. L. (2012). Lessons in biostatistics Interrater reliability : the kappa statistic. *Biochemia Medica*, *22*(3), 276–282.

McMurry, J. (2013). Organic Chemistry. In *Archaeological Chemistry* (8th editio). Cengage Learning.

Ministry of Education, G. (2010). *Teaching Syllabus for Chemistry: Senior High School 1-3*.

Moore, P. J. (2019). Academic achievement. *Educational Psychology*, *39*(8), 981–983. https://doi.org/10.1080/01443410.2019.1643971

Munyaradzi, E. (2013). Teaching Methods and Students' Academic Performance. *International Journal of Humanities and Social Science Invention*, *2*(9), 29–35.

Musyadad, M. A., & Avip, B. (2020). Application of react (relating, experiencing, applying, cooperating, transferring) strategy to improve mathematical communication ability of junior high school students. *Journal of Physics: Conference Series*. https://doi.org/10.1088/1742-6596/1521/3/032048

Nartey, E., & Hanson, R. (2021). The perceptions of Senior High School students and teachers about organic chemistry: A Ghanaian perspective. *Science Education International*, *32*(4), 331–342. https://doi.org/10.33828/sei.v32.i4.8

Owen, L. (2016). The Impact of Feedback as Formative Assessment on Student Performance. *International Journal of Teaching and Learning in Higher Education*, *28*(2), 168–175. http://www.isetl.org/ijtlhe/

Özbay, A. S., & Kayaoglu, M. N. (2015). The Use of REACT Strategy for the Incorporation Of The Context Of Physics Into The Teaching English To The Physics English Prep Students. *Journal of History Culture and Art Research*, *4*(3), 91. https://doi.org/10.7596/taksad.v4i3.482

Özbay, A. Ş., & Kayaoğlu, M. N. (2015). The Use of REACT Strategy for the Incorporation of the Context of Physics into the Teaching English to the Physics English Prep. *Journal of History Culture and Art Research*, *4*(3), 91–117. https://doi.org/10.7596/taksad.v4i3.482

Pallant, J. (2011). *SPSS Survival Manual: A Step by step guide to data analysis using SPSS* (4th edition). Allen & Unwin.

Park, Y. S., Konge, L., & Artino, A. R. (2020). The Positivism Paradigm of Research. *Academic Medicine: Journal of the Association of American Medical Colleges*, *95*(5), 690–694. https://doi.org/10.1097/ACM.0000000000003093

Peng, P., & Kievit, R. A. (2020). The development of academic achievement and cognitive abilities: A bidirectional perspective. *Child Development Perspectives*, *14*(1), 15-20

Petrucci, R. H., Herring, G. F., Madura, J. D., & Bissonette, C. (2011). *General Chemistry: Principles and Modern Applications* (10th editi). MacMillan Publishing Company.

Piaget, J. (1976). Piaget and His School: A Reader in Developmental Psychology. *Physical Therapy*, *58*(3), 375–375. https://doi.org/10.1093/ptj/58.3.375a

Powell, K. C., & Kalina, C. J. (2009). Cognitive And Social Constructivism: Developing Tools For An Effective Classroom. *Education*, *130*(2), 241–250.

Quainoo, B. A. (2019). *Effect Of REACT And 7E Models Of Teaching On Senior High School Students‘ Achievement In Molecular Genetics*. University of Cape Coast Digitized.

Quainoo, B. A., Otami, C. D., & Owusu, K. A. (2021). Effect of the REACT strategy on senior high school students’ achievement in molecular genetics. *Lumat*, *9*(1), 696–716. https://doi.org/10.31129/LUMAT.9.1.1418

Romanus, E., & Ifenyinwa, D. (2020). Learner-Centered Instruction: a Paradigm Shift from Teacher-centered Instruction in the Teaching of Basic Technology in Upper Basic Schools. *Sapientia Foundation Journal of Education, Sciences and Gender Studies*, *2*(3), 177–188.

Saif, M., & Laszlo, K. (2020). Constructivist Theory As a Foundation for the Utilization of Digital Technology in the Lifelong Learning Process. *Turkish Online Journal of Distance Education*, *21*(4), 90–109. https://doi.org/10.17718/TOJDE.803364

Saka, A. Z. (2011). Investigation of student-centered teaching applications of physics. *Eurasian Journal of Physics and Chemistry Education*, *3*, 51–58. http://eurasianjournals.com/index.php/ejpce/article/viewFile/611/285

Sawant, S. P., & Rizvi, S. (2015). Study of Passive Didactic Teacher Centered Approach and an Active Student Centered Approach in Teaching Anatomy. *International Journal of Anatomy and Research*, *3*(3), 1192–1197. https://doi.org/10.16965/ijar.2015.147

Schreurs, J., & Dumbraveanu, R. (2014). A Shift from Teacher Centered to Learner Centered Approach. *International Journal of Engineering Pedagogy (IJEP)*, *4*(3), 36. https://doi.org/10.3991/ijep.v4i3.3395

Sekyere, Kumawu District Assembly. (2021). *Sekyere, Kumawu District Assembly 2018-2021 Medium Term Development Plan Draft Medium-Term National Development Policy Framework , 2018-2021 . An Agenda For Jobs : Creating Prosperity And Equal Opportunity*. 2018–2021.

Shuaibu, A., Ishak, N. A., & Muzirah, M. (2021). Effect of the 7e instructional strategy on the overall attitude of students in biology in public secondary schools in Adamawa State, Nigeria. *Asia Pacific Journal of Educators and Education*, *18*(4), 748–764. https://doi.org/10.36681/tused.2021.101

Sibomana, A., Karegeya, C., & Sentongo, J. (2020). Students' conceptual understanding of organic chemistry and classroom implications in the Rwandan perspectives: A literature review. *African Journal of Educational Studies in Mathematics and Sciences*, *16*(2), 13–32. https://doi.org/10.4314/ajesms.v16i.2.2

Topçiu, M., & Myftiu, J. (2015). Vygotsky Theory on Social Interaction and its Influence on the Development of Pre-School Children. *European Journal of Social Sciences Education and Research*, *4*(1), 172. https://doi.org/10.26417/ejser.v4i1.p172-179

Twizeyimana, E., Renzaho, A., & Mujawimana, E. (2020). Effectiveness of Locally Made Instructional Materials On Students' Academic Performance and Retention in Science Education in Eastern Province of Rwanda. *International Journal of All Research Writings*, *1*(11), 29–37.

Ubulom, W. J., & Ogwunte, P. (2017). Evaluation of Teacher-centered and Learner-centered methods for Instructional Delivery of Senior Secondary Schools Financial Accounting in Rivers State. *International Journal of Innovative Finance and Economic Research* , *5*(3), 81–88. www.seahipaj.org

Ültay, N., Durakan, Ü. G., & Ültay, E. (2017). Evaluation of the Effectiveness of Conceptual Change Texts in REACT Strategy. *Chemistry Education Research and Practice*, 1–38.

Ültay, N., Güngören, S. Ç., & Ültay, E. (2017). Using the REACT strategy to understand physical and chemical changes. *Journal of Social Science Research*, *98*(364), 47–52.

Utami, S. W., Sumarmi, Ruja, N. I., & Utaya, S. (2016). React (Relating, Experiencing, Applying, Cooperative, Transferring) Strategy to Develop Geography Skills. *Journal of Education and Practice*, *7*(17), 100–104. www.iiste.org

Vygotsky, L. (1978). *Mind in Society: The Development of Higher Psychologicak Processes* (M. Cole, V. John-Steiner, S. Scribner, & E. Souberman (eds.); 1st editio). Harvard University Press.

Wade, L. G. (2013). *Organic Chemistry* (8th editio). Pearson Education, Inc.

WAEC. (2017). *Chief examiners' Reports: Science Subjects*. https://waecgh.org/chief-examiners-report/#1679644696468-0aa0c1d6-0482

WAEC. (2018). *Chief examiners' Reports: Science Subjects*. https://waecgh.org/chief-examiners-report/#1679644696468-0aa0c1d6-0482

WAEC. (2019). *Chief Examiners' Report*. *Science Subjects*. https://waecgh.org/chief-examiners-report/#1679644696468-0aa0c1d6-0482

WAEC. (2021). *Chief Examiners' Report*. https://waecgh.org/chief-examiners-report/#1679644696468-0aa0c1d6-0482

WAEC. (2020). *Chief examiners' Reports: Science Subjects*. https://waecgh.org/chief-examiners-report/#1679644696468-0aa0c1d6-0482

Wahyuni, E. S. (2013). The Application of Contextual Teaching Learning Using React in Speaking Practices for Business English Class. *Magister Scientiae*, *34*, 145–158.

APPENDICES

APPENDIX A

ORGANIC COMPOUNDS NOMENCLATURE CONCEPTS TEST

Pre and Post-Intervention Test.

SECTION A

Multiple Choice Questions (20 Marks)

Answer all 20 questions.

For each of the questions, circle the correct answer from the four (4) options given

DURATION: 30 MINUTES

1. The general molecular formular for the alkanes is

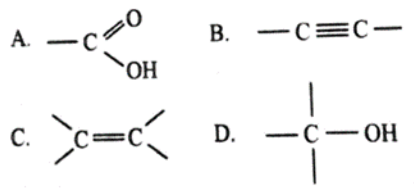
   A. C_nH_{2n}

   B. B.C_nH_{2n+2}

   C. C_nH_{2n+1}

   D. C_nH_{2n+2}

2. The functional group of the alkynes is



3. Which of the following formulae represents an organic compound?

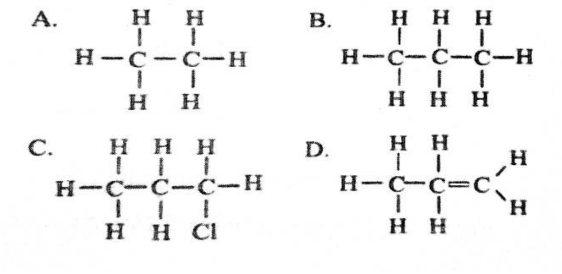
   A. CO

   B. CO_2

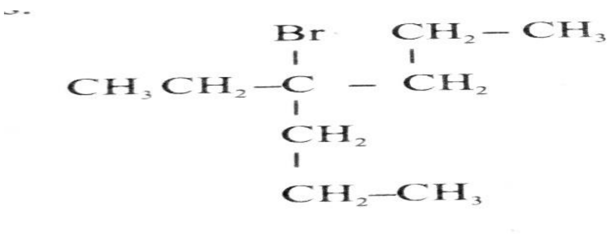
   C. $NaHCO_3$

   D. $C_6H_{12}O_6$

The structural formular of propane is



4. Name the compound below by using I**UPAC** rules.

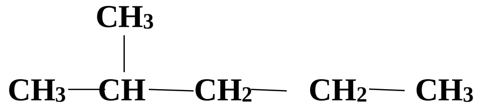


   A. 1-ethyl-1-bromobutane.
   B. 4-bromo-4-ethylheptane
   C. 4-ethyl-4-bromoheptane
   D. 1-bromo-1-ethylbutane

5. The group of organic compounds with the general molecular formular $C_nH_{2n+1}COOH$ are called
   A. alkenes
   B. alkanoates
   C. alkanol
   D. alkanoic acids.

6. Which of the following compounds represents an alcohol?
   A. CH_3COH
   B. CH_3COOH
   C. CH_3CH_2OH
   D. CH_3COCH_3

7. Give the IUPAC name for the compound represented by the structural formulaa,



A. 2- methylpentane

B. 1- hexane

C. 2 – methylbutane

D. 2 – methylhexane.

8. Which of the following pairs of compound belong to the same family?

A. C_4H_{10} and C_5H_{10}

B. C_2H_2 and C_3H_{10}

C. C_2H_6 and C_3H_8

D. C_2H_4 and C_4H_{10}

9. The molecular formular of an alkene containing four carbon atoms is

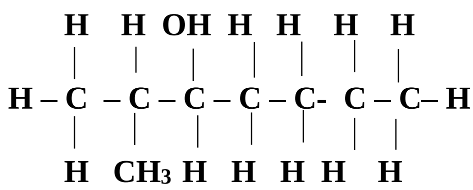
A. C_4H_4

B. C_4H_6

C. C_4H_8

D. C_4H_{10}

10. Give the IUPAC name of the compound below



A. 6-methyl – 5-heptanol

B. 3- heptanol – 2 – methyl

C. 2 – methyl – 3 heptanol

D. 6 – methyl -3 -heptanol

Use the following group of compounds to answer question 12 and 13.

I. Alkanes

II. Alkenes

III. Alkynes

11. The group of compounds belong to a substance generally referred to as

    A. Aromatic compound

    B. Alkanols

    C. Esters

    D. Hydrocarbon

12. Which group(s) have more than single bond.

    A. I and II only

    B. I and III only

    C. II and III only

    D. I, II and III.

13. Which of the following formulas represents an alkenes?

    A. $CH_3CH_2CH_3$

    B. CH_3CH_3

    C. $CH_3CH_2CHCH_2$

    D. CH_3CH_2Cl

14. Select the IUPAC name for:

    $CH\ (CH_3)_2CH_2CH(OH)CH_2C(CH_3)_3$

    A. 2,2,6 – trimethylheptan -4 –ol

    B. 1,1,5,5 – tetramethhyl -3 – hexanol.

    C. 1,1,1,5,5 – pentmethyl -3 –pentanol

    D. 1,1-dimethyl-3-octanol

15. A molecule with the formula, $C_{10}H_{22}$ is a(n):

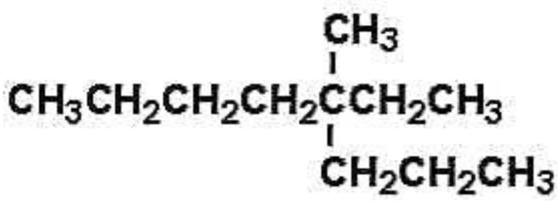
A. Hexane

B. Decane

C. Heptane

D. Octadecane

16. Select the correct IUPAC name for:



A. 5-methyl-5-ethyloctane

B. 5-methyl-5-propylheptane

C. 4-ethyl-4-methyloctane

D. 3-methyl-3-propylheptane

17. What is the molecular formula of an alkane that contain four carbon atoms?

A. C_4H_{10}

B. C_4H_8

C. C_4H_6

D. C_4H_{12}

18. Which of the followings represents propan-1,2,3-ol.

A. CH_2 – OH
|
CH - OH
|
CH_2 – OH

B. CH – $(OH)_2$
|
CH – OH
|
CH – $(OH)_2$

C. CH_3-OH
|
CH_2 – OH
|
CH3 – OH

D. HC –(OH)2
|
HC – (OH)2
|
HC - OH

19. A structural isomer of butane is ...

A. propane.

B. 2-methylbutane.

C. 2-methylpropane.

D. 2, 2-dimethylpropane.

Marking scheme for **Multiple Choice Questions (20 Marks)**

1.B	11. C
2.B	12. D
3.D	13. C
4.B	14. C
5.B	15. A
6.D	16. B
7.C	17. C
8.A	18. A
9.C	19. A
10.D	20. C

[One mark each × 20 = 20marks]

SECTION B

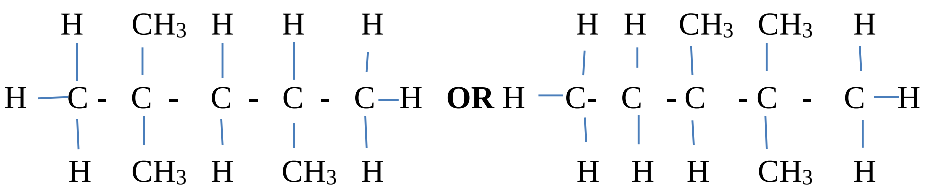
Answer all question in this section

Time allowed: 30 minutes

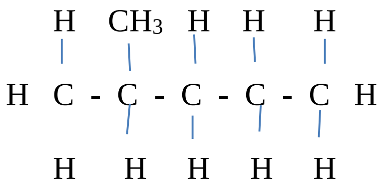
1. Write down the structural formula for 2, 2, 4-trimethylpentane. [2marks]
2. Draw and write the correct IUPAC name of four isomers of the compound, C_6H_{14} , **[8 marks]**
3. Draw structures corresponding to the following IUPAC names: [**6marks**]
   a. 2-methyl-1,5-hexadiene
   b. 3-ethyl-2,2-dimethyl-3-heptene
   c. 2,3,3-trimethyl-1,4,6-octatriene
4. Give correct IUPAC name to the following:
   i. $CH_3CH(OH)CH_2$
   ii. $C_5H_{11}OH$
   iii. $CH_3CH_2C{\equiv}CCH_2CH_3$
   iv. CH2=CHCH2CH2CH2CH3 [4marks]

<u>Marking scheme for theory questions</u>

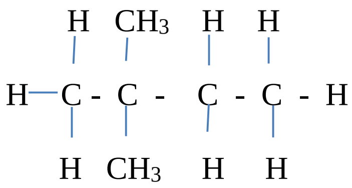
Q1. Structural formular for 2,2,4-trimethylpentane;



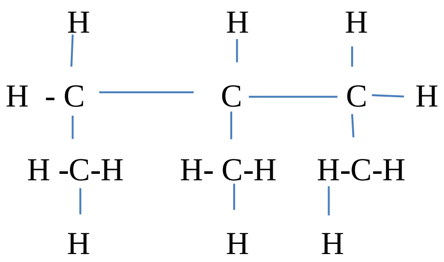
Q2. Structural isomers of C_6H_{14};

i. 

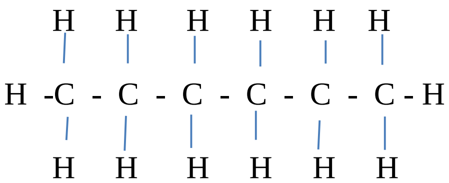
2-methylpentane

ii. 

2,2-dimethylbutatane

iii. 

3-methylpentane

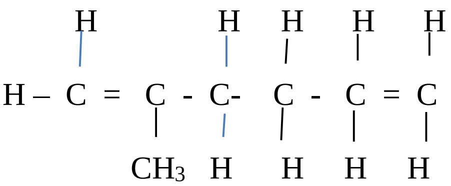
iv. 

Hexane

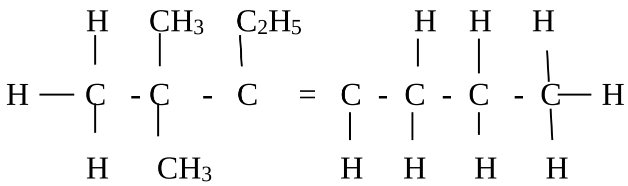
[2marks each x4 =8marks]

Q3.

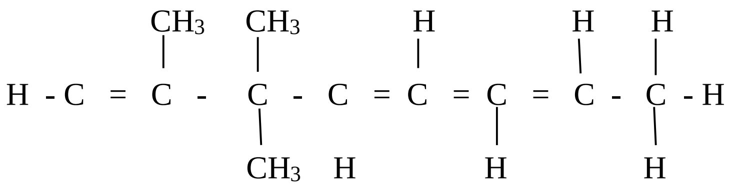
a. Structure of 2-methyl -1,5-hexadeine



b. Structural of 3-ethyl-2,2-dimethyl-3-heptene



c. Structure of 2,3,3-trimethyl-1,4,6-octatriene



[2 marks each × 3 = 6marks]

Q4.

i. Correct IUPAC name of **$CH_3CH(OH)CH_2$**

ANSWER; 2-Propanol or Propan-2-ol. **[1mark]**

ii. Correct IUPAC name of **$C_5H_{11}OH$**

ANSWE; Pentanol or 1-Pentanol or Pentan-1-ol **[1mark]**

iii. Correct IUPAC name of **$CH_3CH_2C\equiv C\text{-}CH_2CH_3$**

ANSWER; 3-hexyne **[1mark]**

iv. Correct IUPAC name of **$CH_2{=}CHCH_2CH_2CH_3$**

ANSWER; Pentyne or 1-pentyne or pent-1-yne **[1mark]**

APPENDIX B

Eta Squared Formular and Interpretation

Eta Squared= $\frac{t^2}{t^2+(N-1)}$

where t= calculated t-value

N= Number of Students

Eta Squared Interpretation

Effect size	Interpretation
≤ 0.1	small effect
≤ 0.6	Medium effect
≥ 1.38	Large effect