UNIVERSITY OF EDUCATION, WINNEBA

SENIOR HIGH SCHOOL STUDENTS' AND TEACHERS' PERCEPTIONS ABOUT ORGANIC CHEMISTRY: A CASE STUDY IN ASIKUMA ODOBEN BRAKWA DISTRICT

ESTHER NARTEY

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of the requirement for the award of degree of Master of Philosophy (Science Education) in the University of Education, Winneba

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DECLARATION

STUDENT'S DECLARATION

I, Esther Nartey, declare that this thesis, with the exception of quotations and references contained in published works which have all been identified and duly acknowledged, is entirely my own original work, and it has not been submitted, either in part or whole, for another degree elsewhere.

SIGNATURE:…….

DATE:…….

SUPERVISOR'S DECLARATION

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

PROFESSOR (MRS.) RUBY HANSON

SIGNATURE :……

DATE:……..……

DEDICATION

This study is dedicated to my parents, Rev. David Williams and Mrs. Veronica Nartey and my brothers Godwin, Emmanuel, Joshua and Matthew Nartey.

ACKNOWLEDGEMENTS

I express my profound gratitude to the Almighty God for His grace, guidance and protection which have seen me through this research work. I also sincerely appreciate the hard work of my supervisor, Prof. Ruby Hanson. Her guidance, constructive criticism, encouragement and correction throughout all the stages of this work has enabled me bring this work to a successful completion. My sincere thanks also go to Dr. Arkoful Sam of the department of chemistry education, University of Education, Winneba for his immense help. A special thank you to my parents, Rev. David Williams and Mrs. Veronica Nartey for their continuous support, encouragement and prayers throughout my studies. I am also grateful to all lecturers of the Department of Science Education, University of Education, Winneba. To my colleagues and friends who supported me in diverse ways, I say God richly bless you!

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LIST OF ABBREVIATIONS / ACRONYMS

MoE	Ministry of Education
OCPQS	Organic chemistry perceptions questionnaire for students
OCPQT	Organic chemistry perceptions questionnaire for teachers
SHS	Senior High School
WAEC	West African Examinations Council
WASSCE	West African Senior School Certificate Examinations

ABSTRACT

The purpose of the study was to determine the perceptions that SHS chemistry students and teachers have about organic chemistry as well as topic difficulties in organic chemistry. The population for the study comprised of SHS students who studied elective chemistry and their teachers. Random sampling (lottery) and purposive sampling methods were used to select 100 students and 10 teachers for the sample of the study. The research instruments used to collect data for this study were the organic chemistry perceptions questionnaire for students (OCPQS) and organic chemistry perceptions questionnaire for teachers (OCPQT). Four research questions offered the framework for presenting the findings. Descriptive statistics (frequencies and percentages) were used to analyze the data collected. The findings revealed that SHS Students have a fairly positive perception of organic chemistry while the teachers had a highly positive perception of organic chemistry. Preparation and chemical reactions of alkenes, preparation and chemical reactions of alkynes, structure and stability of benzene, reactions of benzene, comparison of reactions of benzene and alkenes, petroleum, polymers and naming of alkanes and structural isomerism were perceived by students as difficult to understand. The rest of the SHS organic chemistry topics (26 out of 34 topics) were perceived as easy to understand by students. Also, the teachers perceived all the SHS organic chemistry topics as easy to teach with the exception of reactions of benzene. Polymers and polymerization and petroleum were listed by both students and teachers as difficult for students to understand. It was recommended among others that teachers should use varied methods to teach organic chemistry topics to facilitate easy understanding by students.

CHAPTER ONE

INTRODUCTION

1.0 Overview

This chapter includes the background to the study, purpose of the study, objectives of the study and research questions. The significance of the study, limitations and delimitation of the study are also presented.

1.1 Background to the Study

The science of chemistry involves the study of matter, its properties, the changes that matter undergoes and the energy associated with those changes. It is sometimes called the "central science" because it connects other sciences to each other, such as biology, physics, geology and environmental science. Chemistry is part of everything in our lives and everything we do involves chemistry; from growing and cooking food to cleaning our homes and bodies to launching a space shuttle. Chemists have found a way of dealing with plastic waste by making photo-degradable plastics as well as biodegradable ones. In agriculture, chemical pesticides and fertilizers are used to fight pests and increase plant yield respectively. Food preservatives, flavours, sweeteners and other food additives are added to food to increase the shelf life or for cosmetic purposes. Soaps and detergents which are sodium or potassium salts of long chain fatty acids are used for cleaning in our homes and other places. In the field of medicine, drugs are used to cure as well as prevent diseases. Chemical engineers combine a background in chemistry with engineering and economics concepts to find solutions to problems and develop new products. There are five main branches of chemistry and many areas of study under these branches. They are analytical chemistry, which involves the use of qualitative and quantitative observation to

identify and measure chemical and physical properties of substances; physical chemistry, which is the study of how matter and energy interact; inorganic chemistry, which is the study of materials such as metals and gases; biochemistry, the study of chemical processes that occur within living organisms, and organic chemistry.

Early nineteenth-century chemists defined organic chemistry as the study of compounds that can only be obtained from living matter, which was thought to possess a spiritual "vital force" needed to make these compounds (Petrucci, Herring, Madura & Bissonnette, 2011; Silberberg & Amateis, 2017). Today, we know that the same chemical principles govern organic and inorganic systems because the behaviour of a compound arises from the properties of its elements, no matter how marvelous that behaviour may be. Silberberg and Amateis (2017) define organic chemistry as the study of compounds that contain carbon, nearly always bonded to other carbons and hydrogens and often to other elements like nitrogen and sulphur. This excludes carbonates, cyanides, carbides, cyanates and other carbon-containing ionic compounds that most chemists classify as inorganic.

Many researchers have over the years consistently identified organic chemistry as an area of difficulty (Ayalew & Ochonogor, 2015). Some main topics in organic chemistry identified as difficult by learners in previous researches include:

- Drawing and representation of organic compounds (Johnstone, 2006; Taber, 2002)
- Isomerism (Taagepera & Noori, 2000)
- Properties of organic compounds (Anderson & Bodner, 2008; O'Dwyer & Childs, 2017)

- Classification of organic compounds (Domin, Al-Masum & Mensah, 2008; Donkoh, 2017; Hassan, Hill & Reid, 2004)
- Organic reactions and functional groups (Ayalew & Ochonogor, 2015; O'Dwyer & Childs, 2017; Uchegbu, Ahuchaogu & Amanze, 2017)
- Petroleum (Davis, 2010; Donkoh, 2017;Uchegbu, Ahuchaogu & Amanze, 2017)

Chemistry at the senior high school level in Ghana comprises of physical, inorganic and organic chemistry. The organic chemistry aspect of the Ghanaian senior high school (SHS) elective chemistry syllabus includes hydrocarbons and their reactions, alkanoic acids, benzene, alkanols and their reactions, polymers, carbohydrates, and all these topics have over the years formed an integral part of the final West African Senior School Certificate Examination (WASSCE) conducted by the West African Examinations Council (WAEC). Students are required to score a grade of at least C6 in elective chemistry at the final examination to qualify for further studies in chemistry at the tertiary level.

Over the years there has been a general perception that chemistry, especially organic chemistry is difficult to study and this perception could have led to the general poor performance of students in chemistry. The WAEC chief examiners' reports on Chemistry have over the years reported that the general performance of students was poor and average (WAEC, 2011, 2012, 2014, 2015, 2017, 2018). The chief examiners' comments on students' weaknesses in the chemistry paper two for WASSCE 2017 and 2018 stated that students could not answer the tasks involving organic chemistry, more specifically, recall of terms such as catalytic cracking, aromatic compounds, aliphatic compounds, drawing structures of compounds to show all bonds and drawing how the carbon-carbon double bonds in alkenes are formed.

Much of the research done in chemistry in Ghana focused on the perceptions of students and teachers about chemistry in general and how to improve students' performance in some topics in general chemistry as well as organic chemistry. Only a few (Davis, 2010; Donkoh, 2017) looked at students and teachers perceptions of the organic chemistry topics in the senior high school (SHS) syllabus. Davis (2010) found out that while senior secondary school (SSS) chemistry students perceived 14 out of the 31 organic chemistry topics to be relatively difficult to learn, their teachers found all 31 topics to be easy to teach. Davis also explored the relationship between topics that students perceived to be difficult to learn and topics that teachers found difficult to teach and discovered that there was no statistical difference between them. A study by Donkoh (2017) also revealed that even though students have a negative perception about organic chemistry, it does not make them nervous or bored because they find organic chemistry interesting. None of these researches cited above compared students' difficult topics to topics that teachers perceive to be difficult for students. This reveals a gap in knowledge which the researcher seeks to fill with this study.

It is against this background that this study seeks to find out the perceptions of students and teachers about organic chemistry, find out which topics students find difficult to study and compare them to topics that teachers perceive to be difficult for students as well as suggestions on how organic chemistry should be taught to facilitate easy understanding. This is because perception influences interests and attitude/motivation which in turn can subsequently influence the performance of students in a subject (Asiedu-Addo, Assuah & Arthur, 2017) and comparing students difficult topics to topics that teachers perceive to be difficult for students will help teachers to identify their students weaknesses with regards to studying organic chemistry so that they can be addressed during lessons.

1.2 Statement of the Problem

Chemistry is the branch of science that deals with the study of the structure and composition of matter. Chemistry has often being described as the central science, meaning that the effective study of chemistry lays a solid foundation for the scientific and technological development of an early learner in the sciences.

Students' academic performance in any subject is an important index for measuring the effectiveness of teaching and learning and the extent to which the intended objectives of the subjects are achieved (Okunloye & Awowale as cited in Adesoji, Omilan & Dada, 2017). Some researchers have found out that students' perceptions about a subject can in the long run influence their performance in that subject.

Over the years there has been the general perception among secondary school students that organic chemistry is difficult. At a symposium organized by the American chemical society in 2016, many of the speakers who were educators agreed that organic chemistry has always been in crisis and that students have been saying that organic chemistry is difficult for a long time (Halford, 2016). The problem of students and teachers perceiving organic chemistry as a difficult topic is not exclusive to any one country as many researchers all over the world have over the years consistently confirmed the assertion that organic chemistry is a topic perceived to be difficult by both students and teachers (Ayalew & Ochonogor, 2015). Studies conducted in Ireland (O'Dwyer & Childs, 2017), Zimbabwe (Kazembe & Musarandega, 2012), Nigeria (Uchegbu, Oguoma, Elenwoke & Ogbuagu, 2016) and some other countries have all revealed that high school students and teachers perceived organic chemistry to be difficult for students to learn. In the Ghanaian context, Donkoh (2017) after conducting a study with some selected SHS students and teachers revealed that the students had a negative perception of organic chemistry. The findings from the above

mentioned studies prompted the researcher to interact with some SHS students to find out what their perceptions were concerning organic chemistry. The researcher's interaction with some senior high school form two students in the Asikuma Odoben Brakwa district, most of them mentioned organic chemistry as being difficult; with some complaining about the structures being complex and others talking about the reactions being complex. Although some elective chemistry teachers also admitted that the organic chemistry aspect of the senior high school chemistry syllabus was one of the areas where students found difficulty in learning and understanding, they stated that they themselves did not find it difficult to teach. This difference in perceptions of the students and teachers prompted the researcher to further find out if these perceptions are widespread in the district.

Besides, recent WAEC chief examiners' reports on chemistry (WAEC, 2017, 2018) indicated that the general performance of students was poor. The chief examiner's comments on students weaknesses in the chemistry paper two for WASSCE 2017 and 2018 stated that the students showed the following weaknesses: inability to recall the terms such as catalytic cracking, functional groups, aliphatic compounds, aromatic compounds, inability to draw structures of organic compounds indicating all bonds and drawing how the carbon-carbon double bonds in alkenes are formed. These suggest that students had problems with learning organic chemistry. In 2014, the WAEC chief examiner for chemistry reported that many students did not answer question 5 of the WASSCE Chemistry paper two which consisted of questions on organic chemistry. The chief examiner stated that *"*only few candidates attempted this question and could be attributed to the inadequate preparation of the candidates or the usual fear of organic chemistry" (WAEC, 2014, p. 13).

There is enough evidence in literature to show that students find organic chemistry difficult and some have even suggested that organic chemistry is one of the difficult areas of chemistry (Ayalew & Ochonogor, 2015; Sheehan, 2010). This study was thus designed to find out the perceptions of SHS students and teachers in Asikuma Odoben Brakwa district about organic chemistry and also find out which particular topics in organic chemistry that students find difficult to learn and understand. Students' difficult topics were compared to topics perceived to be difficult for students by their teachers and suggestions were sought from students and teachers on how to make the teaching and learning of organic chemistry more interesting and meaningful.

1.3 Purpose of the Study

The purpose of this study was to investigate the perceptions of SHS students and teachers in Asikuma Odoben Brakwa district about organic chemistry and to examine the topics in organic chemistry that students and teachers find difficult. Students' difficult topics were also compared to topics perceived to be difficult for students by their teachers.

1.4 Objectives of the Study

The specific objectives of this study were to:

1. evaluate the perceptions of SHS science students about organic chemistry.
2. examine how the SHS chemistry teachers generally perceive organic chemistry.
3. identify the specific topics in organic chemistry that the students and teachers find difficult.
4. identify the topics in organic chemistry which the teachers perceive to be difficult for their students.

5. compare the students' difficult topics to the topics that their teachers perceive to be difficult for them.

1.5 Research Questions

The following research questions were formulated from the objectives to guide the study. However, objectives 1 and 2 have been merged into one research question (research question 1) since both of them are assessing perceptions about organic chemistry.

1. What are the SHS students' and teachers' perceptions of organic chemistry?
2. Which topics in organic chemistry do the students and teachers perceive to be difficult?
3. Which topic(s) in organic chemistry do the teachers perceive to be difficult for their students?
4. What are the differences and similarities between the students' difficulty topics and the topics perceived to be difficult for them by their teachers?

1.6 Significance of the Study

The findings, recommendations and suggestions have brought out the perceptions of students and teachers of organic chemistry and also, the difficulties students face in the learning of organic chemistry. These will inform teachers on the problems their students face and help them to choose instructional approaches, strategies and even the length of time to use in teaching the various topics in organic chemistry.

The study could also give useful information to policy makers and authorities in education to undertake interventions to improve students' performance in science, specifically, organic chemistry. The study could also serve as a source of information

for further research work on the topic and has also added up to the pool of data required by educational researchers .

1.7 Limitations of the Study

The sample for this study was taken from senior high schools in the Asikuma Odoben Brakwa district of the central region of Ghana and therefore results from this study cannot be generalized to other students and teachers outside the district.

Questionnaires were used to collect the data so a respondent's dishonesty in responding to any of the questions could affect the validity of the results.

Time and financial constraints were also identified as limitations to this study. This is because the study was conducted within a limited time frame and therefore the researcher had to gather all the information needed for the study within a time frame.

1.8 Delimitations of the Study

The study was confined to selected SHS students and teachers in the Asikuma Odoben Brakwa district who had studied or taught organic chemistry. The study was also delimited to finding out the perceptions of students and teachers towards the teaching and learning of organic chemistry. The other branches of chemistry were not included in this study.

1.9 Organization of the Thesis Report

This thesis report consists of five chapters. The first chapter provides an introduction to the study. It also includes statement of the problem, purpose of the study, research questions, and significance of the study, limitations and delimitations of the study. The second chapter consists of a review of related literature. The third chapter outlines the detailed information of the research methodology employed in the study.

The fourth chapter presents the data collected, their analysis and discussions. The fifth chapter presents the summary of the study, findings, conclusions, and recommendations.

CHAPTER TWO

LITERATURE REVIEW

2.0 Overview

This chapter discusses relevant literature related to this study. The literature is discussed under headings which include the theoretical foundation which is based on the constructivist theory. Perception and the perceptual process, empirical evidence of difficult topics in organic chemistry and reasons for difficulty, students' performance in chemistry, difficulties in learning organic chemistry, difficulties in teaching organic chemistry and teaching for meaningful learning of organic chemistry have also been discussed in this chapter.

2.1 Theoretical Foundations

The main theoretical foundation for this research is constructivism. Constructivism was defined by Piaget (1973) as the construction of new knowledge and understanding based on what people already know and believe. Based on the constructivist belief that new knowledge is formed using prior knowledge, teachers and professors must be aware of misconceptions, alternative conceptions, incomplete comprehension, and preconceptions of students so that they can be addressed in order for students to achieve higher learning and understanding. This is because students' misconceptions have the ability to hinder understanding of subsequent related concepts and prevent further learning (Hanson, 2020). During the past two decades, constructivism has become more widespread in the teaching world and the resulting paradigm shift from objectivism to constructivism has caught the attention of many educational researchers. This idea has become the basis for many teaching programs as well as learning style approaches (McLeod, 2019). Before addressing where

constructivism is going and its place in this research, it is important to know from where constructivism has come, its roots, and its origins.

The field of constructivism has many key theoreticians who have performed the most relevant research in the field. Jean Piaget, John Dewey, Immanuel Kant, Thomas Khun and Lev Vygotsky (Phillips, 2007) are some of the major constructivist theorists. These intellectuals have dissected the theory of constructivism into two main subcategories: cognitive and social constructivism. Jean Piaget set forth the first theory of cognitive constructivism. Piaget believed that each person has the cognitive ability to construct new material on their own. In this theory there is little reliance on other people, and instead it is reliant only on oneself thereby proposing that everyone must build their own knowledge for themselves. The primary limitation to cognitive constructivism is the misunderstanding associated with some terms in Piaget's research. Piaget used many terms whose meanings to him do not align with the common meanings others give to them. Some of these terms are 'truth' and 'verification'. This has created disequilibrium and has caused his work to be a source of many misunderstandings in the study of constructivism (von Glasersfeld, 1992).

Lev Vygotsky had ideas that better align with the current research. Vygotsky's theory is that of social constructivism. The social constructivism belief is that a student interacts with other students (peers) and from this interaction and their prior knowledge/experiences, constructs the new information. Vygotsky's theory is centered on the zone of proximal development. The author professes that when someone is in this zone, which is a small range of time, a knowledgeable person must share what they know with the novice. During this stage, or while in this zone, the novice is the most impressionable and vulnerable to learning new information (Vygotsky, 1978). This theoretical foundation of constructivism (both cognitive and

social) is therefore the basis for this research. The idea that students construct knowledge independently (cognitive) as they proceed throughout their academic career shows that they incorporate new knowledge, or preconceptions that they may have in their mental framework. It is important that students are constructing not only correct knowledge but knowledge that will allow them to continue construction. However, perceptions may be formed and incorporated into a student's construction during social interactions. Perceptions heard from other students or teachers (usually referred to as preconceptions), may cause students construction (social) to become hindered, therefore, affecting their ability to successfully learn and understand new material. It is for these reasons that constructivism, both social and cognitive, is the theoretical framework for this research.

2.2 Perception

The definitions and theories of human perception is highly dependent on the discipline of study and is therefore inconclusive. It is however evident from literature that it is in the fields of psychology and philosophy that these definitions and theories are used. In light of the above, some general definitions of perception are provided below.

Perception is defined as "the way you notice things" (Oxford Advanced American dictionary, 2020, Definition 1). It is also defined by the Cambridge advanced learners' dictionary (2020, Definition 1) as "a belief or opinion, often held by many people based on how things seem". For the purpose of this research, the general definition of perception as an understanding of the world constructed from information obtained by means of the senses (Shazer as cited in Lewis, 2001) will be adopted.

Perception allows us to take sensory information in and make it into something meaningful. Your perception of something is the way that you think about it or the impression that you have of it. For perception to take place, there is an experiencing person or perceiver, something to be perceived (either an object, person, situation or relationship), the context (environment) of the situation in which objects, events or persons are perceived (Saks & Johns, 2011) and finally, the process nature of perception starting with the experiencing of multiple stimuli by the senses and ending with the formation of percepts. Although perception may seem like a separated and slow process, the formation of percepts takes milliseconds to complete and does not occur in fragments.

2.2.1 The perceptual process and influencing factors

Lewis (2001) explained that in order to understand how humans give meaning to their world, one has to understand the perceptual process as well as the various influencing factors. The four stages of Randolph and Blackburn's model as cited in Lewis (2001) is presented below to explain the perceptual process.

From the definitions of perception cited earlier, it is clear that the first step in the perceptual process is the experiencing of multiple stimuli by means of the five senses. It should also be noted that physiological differences and deficiencies in individuals may cause them to perceive differently. How you see or experience the world is limited to what your senses tell you.

Secondly, the human senses observe an enormous amount of information and therefore makes it impossible for all the information to be processed at once and therefore humans will select those which they want to pay attention to (Heim & Keil, 2017). This process is referred to as observation and selection of focus. Humans

choose their focus after observing stimuli based on a range of factors within the perceiver, the perceived target and the situational context in which the perception is made. Some of these factors are outlined below.

Various researchers identify and emphasize that certain characteristics of the perceiver can modify perception. Some of these factors are what the individual has previously learnt, the motivation and the personality of the perceiver, physiological factors, gender, as well as personality and cognitive differences, attitudes, interests, motives, experience and expectations of the perceiver.

If one looks at an object or subject, you form perceptions of what you see due to it having certain characteristics. Some factors that influence perception which relates to the object being perceived are novelty (unfamiliarity) of the object, motion (a moving object/ person tends to get more focus), sounds, size, background, proximity (how close the object is to the perceiver), repetition (repeated stimuli will often receive more attention) and the relationship of an object/subject to its background (contrast). The context or situation in which objects or events are perceived also influences subsequent thoughts and behavior. Other factors such as the cultural context, the social situation as well as the location and time of an incident all have a major influence on the object/subject being perceived.

Thirdly, after stimuli of a person or object has been experienced by the senses within a specific situation or context, they are processed through the frame of reference filter. This forms the initial phase of the attribution of meaning to the experienced phenomena. In this frame of reference process, the characteristics of the perceiver become dominant with past and present experiences rendering a major role. Past experiences are associated with particular emotions and cognitions and when similar

present experiences are encountered, humans tend to rely on past feelings and thoughts to interpret the perceived phenomena (New York University, NYU School of Medicine, 2018)). Present experiences also play an important role in the perceptual process and may even modify and influence past thoughts and feelings unless if the perceiver intentionally blocks out their influence (Johnson, as cited in Lewis, 2001).

The final step in the perceptual process model of Randolph and Blackburn (as cited in Lewis, 2001) is the assignment of meaning to the perceived phenomena that have been selected and processed through the previously mentioned frame of reference filter. In order to understand other people and our own behavior, the process of attribution comes into operation. With reference to a social context, while observing other humans in specific situations, humans make judgements about others and attribute meaning based on observed behavior (Baron & Byrne, 2000). Many researchers (Baron & Byrne, 2000; McLeod, 2012; Tyson, as cited in Lewis, 2001) have come out with explanations for the attribution process. Although there are different explanations, they all agree that a person's behavior was either caused internally (for example, by motives and intentions), externally (some aspect of the social or physical world) or due to a combination of the two. While attribution models are generally valid, Tyson as cited in Lewis (2001) cautions that there are systematic biases which exist and which can lead to serious errors in the judgements we make. Cherry and Lehman (2020) agree and further assert that in many instances certain attributions may be incorrect as not all the information is considered when attributing a cause to a specific behavior. Common errors in attribution may be the fundamental attribution error (also known as the correspondence bias) and the self-serving bias. The fundamental attribution error is the tendency to overestimate the influence of internal factors and underestimate the influence of external factors when judging

others' behavior while the self-serving bias is when individuals attribute internal factors to their own successes, while blaming their failures on external factors (Cherry & Lehman, 2020). Figure 1 provides a summary of the perceptual process.

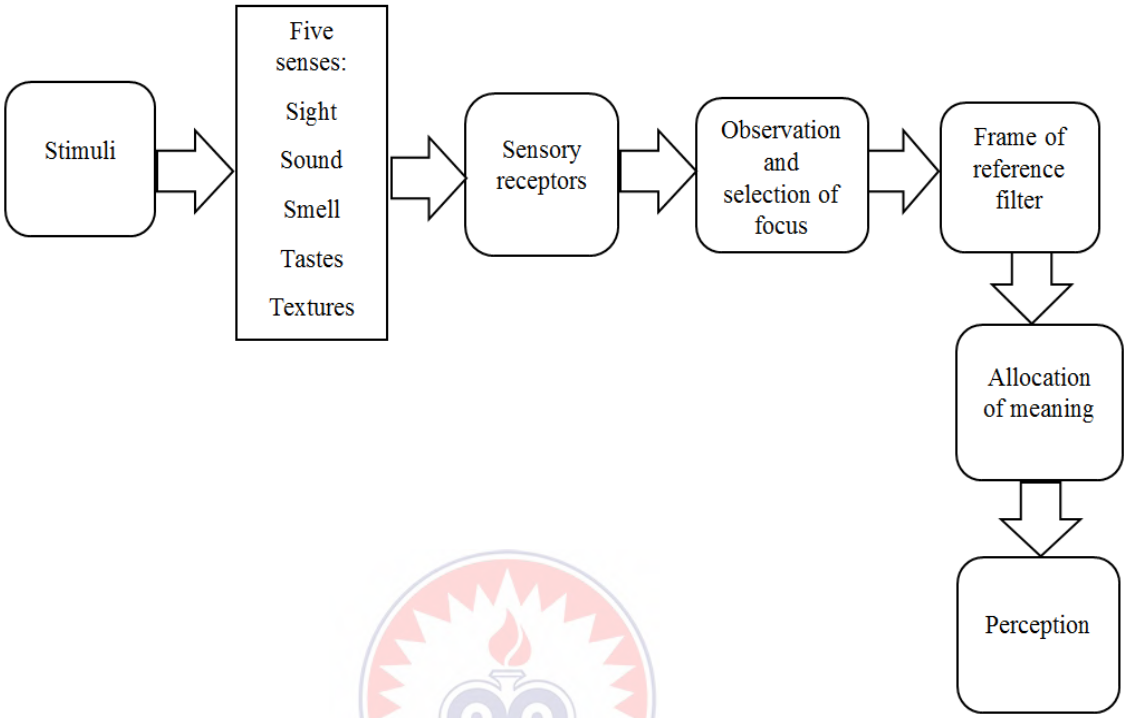

Figure 1: The Perceptual Process (Adapted from Draskovic, Temperly & Pavicic 2009)

2.3 Difficult Topics in Organic Chemistry and Reasons for Difficulty

Several research reports have shown that organic chemistry is a difficult subject for students who pursue their education in this career (Johnstone, 2010; O' Dwyer & Childs, 2011; Ayalew & Ochonogor, 2015) but their reasons for the difficulty may differ. According to Ellis (1994) as cited in O'Dwyer and Childs (2017), the difficulty faced by students in learning organic chemistry is due to the fact there are no algorithms for solving organic chemistry problems, it requires three-dimensional thinking and that the new vocabulary to be learned in organic chemistry is very intensive. Some researchers (Ayalew & Ochonogor, 2015; O'Dwyer & Childs, 2017)

have also indicated the following as reasons for students' difficulties in organic chemistry:

1) The nature of chemistry concepts and the way the concepts are represented (macroscopic, microscopic or representational);
2) Methods by which students learn are potentially in conflict with the nature of science or the methods by which teachers have traditionally taught;
3) Teachers' lack of an accurate awareness of their pupils' prior knowledge, misconceptions, level of cognitive development of students;
4) Students' attitudes and approach to learning.

In Ghana, Hanson (2014, 2016) has identified that the inability of students to understand the nature of matter and connect among the three representational levels of matter are the main factors that impede their study of chemistry. According to Hanson (2017), students are most of the time unable to understand these representations very well and thus form faulty and weak basis for further study of chemical concepts, especially in organic chemistry. In this section, some research reports that investigated the topics that students find difficult in organic chemistry as well as reasons for the difficulties have been reviewed.

Results of a study conducted by Uchegbu, Ahuchaogu and Amanze (2017) to examine the perception of difficult topics in the organic chemistry curriculum in Imo (Nigeria) showed that the students perceived twelve topics in the organic chemistry curriculum as difficult. These topics included petroleum, aromatic compounds, heterocyclic compounds and synthetic polymers. The study also revealed some reasons why chemistry students find some concepts difficult to learn. Some of the reasons given by the students in this study for the difficulty are that they see organic chemistry as a subject that demands too much of molecular structure, they find reaction mechanisms

to be difficult to understand and also the fact that organic chemistry laboratories in the tertiary institutions are not well equipped for practical work.

In an investigation of second level Irish pupils' and teachers' view of difficulties in organic chemistry by O'Dwyer and Childs (2017), 59.8% of the sample found organic chemistry difficult, 57.2% enjoyed studying it and 44.9% agreed that it was interesting. The main reason given by the students who found organic chemistry to be easy to learn was that organic chemistry is logical and can be learned systematically. Many of these students also found the subject interesting and relevant to their own lives. In comparison, the most common reason given by the other students for finding organic chemistry difficult to learn was the length and detail of the course. Difficult topics listed by students were: differentiating the functional groups, naming and drawing compounds and organic formulae. Organic reactions and functional groups were listed among the top five most difficult topics. Organic mechanisms was listed as the number one most difficult topic by the highest number of pupils (53, 19.2%). However, organic reactions had the highest aggregate score as it was listed as difficult by 135 (48.9%) of the pupils.

Another study by Ayalew and Ochonogor (2015) to investigate specific areas of difficulty for students in organic chemistry and to identify the sources of difficulty for chemistry students revealed the main areas of difficulty identified by teachers and students as functional groups and organic reactions among other selected topics. Some factors and reasons given by students for the difficulties are inappropriate chemistry teachers' teaching methods, nature of the subject itself (intrinsic difficulty of the subject), students' attitude towards learning, learning experience and learning style of students. All the factors listed by the students in this study agree with what many

psychology researchers propose to be the factors that influence perceptions which are related to the perceiver. A lot of chemical education researchers have stated that the difficulties in chemistry arise from the abstract, complex and dynamic nature of the concepts covered, bulky course content, teacher-centered teaching, erroneously constructed students' knowledge due to lack of clear vision, and lack of students' and teachers' motivation (Ayalew & Ochonogor, 2015). Millar, as cited in O'Dwyer and Childs (2017)) has categorized the factors which contribute to difficulty of organic chemistry as extrinsic difficulties (factors referring to issues that are beyond the control of learners); and intrinsic difficulties (factors referring to difficulties faced by individual learners and supposed to be within their control). From the studies reviewed above, it has come to light that some main topics in organic chemistry are perceived to be difficult and the difficulties can either be intrinsic or extrinsic.

Searches through available literature revealed that very little has been done in the area of perceptions of organic chemistry in Ghana. Davis (2010) in investigating Ghanaian senior high school (SHS) students' and teachers' perception of organic chemistry topics found aromatic hydrocarbons to be the most difficult topic for both students and teachers. The researcher categorized the reasons for students' difficulty given by students into teacher factors, students' perceptions and learning difficulties. Some reasons for students' difficulty given by teachers included complexity of the topic, abstract nature of the topic and students' poor background in chemistry from the basic schools. In contrast, Donkoh (2017) found out in his study on students' and teachers' perception of very difficult SHS organic chemistry topics that the teachers did not perceive any of the SHS organic chemistry topics very difficult to teach while students' perceived reactivity of organic compounds, petroleum, benzene, alkanoic

acids, alkanoic acid derivatives, amino acid functional groups, natural and synthetic polymers as very difficult topics to understand.

The researches done in the area of chemistry perceptions, and more specifically, organic chemistry perceptions in Ghana displays a gap in knowledge. Although Davis (2010) and Donkoh (2017) have researched on topics that Ghanaian SHS students find difficult to understand and topics that Ghanaian SHS teachers find difficult to teach, none of these researches compared students' difficult topics to topics perceived to be difficult for students by teachers and this research seeks to fill that gap. Since research has shown that perceptions about a subject could affect attitude and motivation and eventually performance in a subject, they should be addressed and taken seriously. By successfully identifying students' perceptions, teachers can be able to tailor their instructions to ensure effective teaching and learning of the subject.

2.4 Students' Performance in Chemistry

Most students perceive organic chemistry to be difficult, hence perform poorly in the subject. Although, the study of organic chemistry may be complex, yet it is very important, not only to those who are interested in science-related careers, but also to every individual living today and to those who will be born in the future. Organic chemistry is a key to developing new products and improving those on which we have become dependent. Although there is strong emphases on organic chemistry, students commonly consider it a big obstacle to the study of chemistry as a discipline (Coll, 2014). Most students find science difficult and physical sciences such as chemistry and physics are especially problematic. Coll (2014) further explained that many students are doing a given subject, say chemistry, not by choice but because it is

required as part of the program they pursue. Such students have low interest towards studying chemistry and subsequently may not perform well in chemistry.

Nbina (2012) and Njoku (2007) have bemoaned the poor and deplorable performance of Nigerian students in chemistry at the secondary school level over the years. Analysis of students' performance in the science at senior school certificate examinations (SSCE)/WASSCE level as noted by Njoku (2007) revealed that between 2000 and 2010, the annual average pass rate at credit level (grade A1-C6) in chemistry was 15.41%, while the absolute failure rate (grade F9) was 61.82%. In Ghana, the teaching of organic chemistry is taken seriously and so all secondary school children learn some amount of it as well as its many benefits to mankind. However students' academic performance in chemistry in general has been poor (Hanson, 2017). Adu-Gyamfi, Ampiah & Appiah (2013) revealed that Ghanaian SHS students showed low performance in IUPAC nomenclature of organic compounds. A comparative study of the performance of regular senior high science students and remedial senior high science students in WASSCE from 2007-2016 by Essibu (2018) also revealed that out of the 3 elective science subjects (chemistry, biology and physics), chemistry was the least passed subject for both groups of students. Furthermore, the WAEC chemistry chief examiners' reports for Ghana have consistently stated that most students who attempt organic chemistry questions in papers 2 and 3 do not perform well in the organic chemistry questions (WAEC, 2011, 2012, 2013, 2014, 2017, 2018). Okebukola's (2006) findings on factors affecting students' performance in practical chemistry revealed such factors as students' participation in chemistry laboratory activities, teachers' attitude to chemistry as a subject and adequacy of laboratory equipment for practical work. Successful completion of organic chemistry is a prerequisite for many graduate and professional

programs in science, technology, engineering, and mathematics, yet the failure rate for this branch of chemistry is notoriously high. The lack of practical activities by chemistry students has resulted in poor communication and observational skills. The absence of these skills gave rise to students' poor performance in chemistry especially organic chemistry.

2.5 Difficulties in Learning Organic Chemistry

Organic chemistry has a general reputation of being a difficult subject for both students and teachers (O'Dwyer & Childs, 2011). There are many factors that make chemistry not only a difficult subject to learn, but one that is difficult to understand. According to Ellis as cited in O'Dwyer and Childs (2017), the three main difficulties for those learning organic chemistry are: there are no problem-solving algorithms, it requires three-dimensional thinking (macroscopic, microscopic and symbolic) and it has an extensive new vocabulary. To understand organic chemistry concepts, students and teachers alike must do three-dimensional thinking. Students and teachers must move back and forth through macroscopic, sub-microscopic and symbolic domains (Johnstone, 2010). The 'macroscopic' level refers to what is tangible and visible, for example, a beaker of water is a clear colourless liquid. The 'sub-microscopic' level refers to what is molecular and invisible, for example, the molecules (atoms and bonds) that make up water. The third dimension, that is, the 'symbolic 'refers to the chemical symbols, formulae and equations that represent the molecules and atoms, for example, a molecule of water is represented as H_2O. While a teacher, lecturer or professional chemist may be able to easily navigate through these domains of thought, the combination of any two of these dimensions, or even the comprehension of one dimension, can be demanding for a learner who has a limited prior knowledge and understanding of chemistry and thus the learner easily gets lost or stuck and complain

that organic chemistry is difficult. Out of the three domains described above, it has been found that the symbolic domain poses a greater difficulty (Childs & Sheehan, 2009; Graulich, 2015). A study by Hanson (2014, 2016) on Ghanaian students has also identified students' inabilities to understand the nature of matter and how to connect among the three representational levels of matter as the main limiting factor in their study of chemistry. According to Hanson (2017), students are often unable to thoroughly understand these representations and so form faulty and weak basis for further study of chemical concepts, especially, in organic chemistry

Sirhan (2007) proposed that to reduce students' frustration and difficulty, teachers have to teach and make the link between the sub-microscopic, macroscopic and symbolic levels very clear to their students. Sirhan further explained that an additional instruction in linking the sub-microscopic level to macroscopic and symbolic has been experimentally found to be effective in facilitating students' understanding of chemistry concepts.

In talking about difficulties faced by students in learning organic chemistry, Ayalew and Ochonogor (2015) asserted that organic molecules are usually three-dimensional, however, they are drawn in textbooks and on chalkboards as two-dimensional structures. The students and teachers then have to visualize the two-dimensional structures in their three-dimensional forms for better understanding. As many students do not have the cognitive ability to effectively do this transformation, they are left with no option than to memorize a large vocabulary of molecules by rote (Donkoh, 2017). In a case study by Anderson and Bodner (2008) to find out why a student did not understand organic chemistry, they found that organic chemistry was difficult for the student because he got stuck at the symbolic domain. His major challenge had to

do with visualizing three dimensional structures from the two-dimensional structures in books and interpreting molecules and reactions. This challenge made him resort to memorizing rules and becoming what is termed as an instrumental learner. Skemp as cited in Anderson and Bodner (2008) defines instrumental learning as "recognizing a task as one of a particular class for which one already knows a rule in contrast to relational learning, which involves relating a task to an appropriate schema" (p. 97).

Piaget's model of cognitive development suggests that the cognitive ability and development of the learner depends on their age. It therefore means that according to Piaget's theory, a learner at the formal operational stage of development (11 years through to adulthood) can do abstract and logical thinking. More recent research has shown Piaget's ages to be too optimistic. O'Dwyer and Childs (2017) cited researches carried out in 1981 by Shayer and Adey in the UK and again in 2007 by Shayer, Ginsburg and Coe to show that the percentage of pupils at age 16 who have reached the formal operational stage was much lower than previously thought. In another work on Irish pupils and students by Childs and Sheehan (2010), the results showed that less than 20% of pupils at senior cycle in second level and less than 40% of students at third level were operating at the highest level of Piaget's cognitive development. The average age of the pupils beginning the senior cycle according to O'Dwyer and Childs (2017) is 16. If these findings are generally true, then it would have important implications on teaching and learning of organic chemistry at the Ghanaian SHS level as the average age of Ghanaian SHS students is also around 16 years. This is because organic chemistry requires abstract thinking and students would have to operate at the formal operational stage to be able to learn it and even though the researcher has not come across any extensive work done on the cognitive development of Ghanaian SHS students, the age similarity between the Ghanaian SHS

students and the students in the studies cited above could be used to safely suggest that majority of Ghanaian SHS students start the elective chemistry course without the ability to think in an abstract and conceptual manner. This could lead to students encountering a lot of difficulties in learning organic chemistry because Adey as cited in O'Dwyer and Childs (2017) found out that to be able to learn and understand core organic chemistry ideas, students need to be at the formal stage of cognitive development. It is therefore not surprising that various researchers have found student difficulties in learning organic chemistry since most of these students have not reached the formal stage of cognitive development. In teaching organic chemistry, it is critical that educators are aware of the cognitive level and ability of their learners, if not the learners will be overwhelmed by the multi-level cognitive demands of chemistry as well as the other scientific and mathematical demands of the subject (O'Dwyer & Childs, 2017).When learners lack the cognitive ability necessary to learn and understand the topics encountered on their courses, alternative approaches such as rote learning may be adopted, as was the case of the subjects in Anderson and Bodner's (2008) research work.

There also is overwhelming empirical evidence in the literature that what students already know plays a key role in learning. Usually students' pre-instructional conceptions provide frameworks that are not in accordance with the science conceptions to be learned. From a constructivist perspective, which is the predominant contemporary view of learning in science education, every observation and every sensual input of any other kind has to be interpreted by the receiver. Students construct their own meanings of observations that they make when experiments are presented, pictures are shown, and explanations are given by the teacher or the textbook. The only interpretive frameworks that students possess are the conceptions

gained in daily life or in science classes. As a result, in making sense of what is presented in science classes and in textbooks, sometimes students construct meanings that are in contrast to the expected chemistry view. Within this constructivist perspective, learning is not seen as the intake of knowledge that is delivered by the teacher and teaching is not viewed as transfer of knowledge from teacher or textbook to the head of the students. Rather, learning is viewed as an active construction process of the learner and teaching is designed to support and nurture this construction process. Accordingly, learning science can be a painstaking process of a sequence of gradual changes of students' pre-instructional conceptions towards science conceptions. The term conceptual change is usually employed to point to this process because it denotes that major changes of the initial conceptual frameworks are necessary when science concepts and principles are learned.

Millar as cited in O'Dwyer and Childs (2017) as stated early on has categorized learner difficulties into two domains: intrinsic difficulties and extrinsic difficulties. Intrinsic difficulties refer to difficulties relating to cognition and the process of learning, while extrinsic difficulties refer to difficulties associated with the subject itself, beyond the control of the learner. Some researchers have outlined the extrinsic factors that contribute to difficulties in organic chemistry as: the multidimensional nature of chemistry, complex language of chemistry, chemistry's relationship with mathematics, laboratory work and the chemistry curricula in general. Also some extrinsic factors are cognitive ability of learners, how learners process information, learners' attitudes towards the learning of organic chemistry and misconceptions. Many of the extrinsic factors are beyond the control of teachers and learners. However, addressing some of the intrinsic factors is within the capabilities of teachers and learners who are willing to share and develop together (O'Dwyer & Childs,

2017). It is therefore important that in this research work the difficulties encountered in the teaching and learning of organic chemistry are discussed and although the focus of this research was not to 'fix' these difficulties, possible ways of overcoming these difficulties were also discussed.

2.6 Difficulties in Teaching Organic Chemistry

Chemistry content, and even science content in general, presents teachers with many difficulties when deciding how to teach a course. Chemistry content is conceptually difficult to understand and there are therefore a lot of obstacles that teachers must overcome to achieve success in their classroom. The way in which concepts are introduced is the greatest problem in teaching chemistry. The concepts should be taught in a way that will enable the student to truly learn chemistry, without just rote memorization of definitions or use of formulas and words without fully understanding their meaning. Hanson (2016) further asserts that most chemistry concepts are abstract and to alleviate their abstractness, teachers would need to concretize these concepts to enable students form mental models which will enhance comprehension. Ideally, the words or concepts used by the students should gradually become a way of thinking. Teachers usually complain about lack of interest on the part of students but could this lack of interest be a direct result of the science teachers' teaching methodologies? It should also be noted that this lack of interest on the part of students often discourages teachers from searching for more innovative ways of teaching and evaluating learning (Lima & Vasconcelos, 2006). Lopes (2005) argued that school disciplines should not be the mere reproduction of scientific knowledge, they should have social purposes. Lopes also asserted that many areas of content that are considered important are organized and included in the curriculum, in school books and delivered in class, and sometimes without contributing significantly to the education of the student/citizen.

This means that students are taken through content without them getting to know the useful applications of the content in their lives/ everyday life. This fact may contribute to the student's lack of interest and dedication, which creates a vicious cycle of lack of understanding of concepts and a consequent teachers' lack of motivation. To remediate this, Hanson (2017) suggested that teachers can begin their lessons by asking questions related to everyday life events and then the context of the properties or answers could be steered to the classroom and its scientific or chemical aspect emphasized through individual, small group and whole class discussions.

Added to the above is the extensive content included in the SHS chemistry syllabus. In the case of organic chemistry, the syllabus is so extensive that it cannot be thoroughly covered, or it is covered only superficially, which can give rise to the misconstruing of concepts (misconceptions) and lack of correlation with previously taught content. Sometimes also, the need to prepare students for the West African Senior School Certificate Examinations (WASSCE) and the extensiveness of the content makes teachers rush through or sometimes skip certain aspects of organic chemistry which in their view is not likely to appear in the WASSCE.

In general, the science teacher has historically been exposed to a series of challenges that include keeping up with scientific and technological discoveries, staying up to date on environmental problems and making all this information accessible and pleasant to the students. In other words, teaching involves making the unfamiliar familiar, and this huge task rests on the teacher. Besides the challenges science itself poses to the teacher, teachers are also faced with crowded classrooms (more than forty students in a class) which makes it difficult for teachers to monitor individual

student's progress; professional devaluation and outdated school facilities (including laboratory facilities and equipment), especially in public schools.

A large number of chemistry teachers in secondary schools have reported difficulties and problems related to teaching this discipline (Quadros et al., 2011). It is not enough for teachers to know the content to be able to teach it but they must also have knowledge about how to teach, how to articulate content, and what the basic knowledge required from every student is, that is, what the students are required to learn. In a study by Quadros et al. (2011) aimed at investigating syllabus- related difficulties faced by the teachers of chemistry in secondary schools in Brazil, organic chemistry was the second highest chemistry discipline that was reported as difficult to teach by the teachers. Carbon hybridization, atomic and molecular orbitals, organic reactions, and mechanisms of reaction are part of the topics which were mentioned as difficult. Quadros et al. were worried that with some schools doing as low as two hours of chemistry per week, the intended depth for some of the topics like reaction mechanism would not be achieved and that most teachers probably reserved the organic chemistry part to be taught in the third year of senior high school. In Ghanaian SHS, although chemistry is taught 4 hours a week (two hours for theory and two hours for practical), most teachers reserve organic chemistry for third year and end up either not teaching it at all or rush through topics. If the content is not understood from the chemical viewpoint, the students would have no option than to do rote memorization. The atoms and molecules involved in chemical reactions have real structures that cannot be perceived by the senses and therefore the question that arises is, how can you teach or study something that cannot be perceived by the senses? The correlation between the behavior of these minute particles that constitute the microscopic and lend properties to the macroscopic system was and continues to

be a great challenge of teaching chemistry (Roque & Silva, 2008). Roque and Silva further stated that in an attempt to facilitate the teaching of such content, some teachers reported using analogies, contextualization, multimedia resources (slides) or videos, and physical models (balloons or plastic models to represent molecules). The combination of these strategies/resources can make learning concepts more significant, increasing the interest of the students in organic chemistry. However, despite their efforts, the teachers still recognize that a large number of students do not learn and do not like organic chemistry.

2.7 Teaching for Meaningful Learning of Organic Chemistry

It has been noted by many researchers (Johnstone, 2010; O'Dwyer & Childs, 2017) that there seems to be a disconnection between the enthusiasm of chemistry teachers and the interest levels of their learners. The mere fact that teaching has taken place does not mean that learning has also taken place (Anderson & Bodner, 2008). According to Vallori (2014), we can say meaningful learning has taken place only when the learner has been able to integrate the new knowledge into their existing cognitive structure; then changes are produced in their cognitive structure, concepts are modified and new links are created. Meaningful learning is useful because it enables real learning, generates greater retention and facilitates transferences of what has been learnt to other real situations (Vallori, 2014).

Ausubel and Novak's assimilation theory (as cited in Grove & Bretz, 2012) emphasizes that teachers and learners should be aware of meta-cognition as a continuum from rote memorization to more meaningful learning. Grove and Bretz further explained that when learners lack the cognitive ability necessary to learn and understand the topics, they most likely resort to rote memorization and meaningless

learning. Novak (2010) has indicated that the learners' feelings, motivation and attitudes (affective domain) are important for meaningful learning to occur. Novak's (2010) theory of education defines meaningful learning as the constructive integration of thinking, feeling, and acting. This shows that meaningful learning should involve the combination of cognitive (mental), affective (feelings) and psychomotor (skills) learning (Galloway, Malakpa & Bretz, 2016).

Vallori (2014) detailed some essential principles for meaningful learning. Some of these principles are outlined below.

1. Open works

   Vallori explained that open works are which enables every learner to make a product. Teachers can plan the topics according to the curriculum and provides the needed materials and support for learners to come out with the products. This way, students' learning is reinforced. This can be put into use in the chemistry classroom through practical activities such as using molecular models to form different given compounds and even practical laboratory activities.

2. Collaborative work

   Collaborative work involves putting students in groups/teams to work together on a given assignment/project. Students work fine and learn better when cooperating in pairs, although a group of 4 is considered ideal. It is however important that teachers put students of different abilities in a group, that is, teachers should put together in a group a high ability learner, an active one (capable of leading the group), a slow-witted or withdrawn student and a learner using curriculum adaptation (with special educational needs, bad behaviour, etc.). Also, learners with poor interpersonal skills will be able to interact more effectively with others as a result.

3. Concept mapping

   Where possible, concept maps which involve the linking of concepts to each other in a hierarchical way can be used to teach. In concept maps, concepts are arranged in hierarchies, starting from the most inclusive, most general concepts at the top of the map and the more specific, less general concepts arranged hierarchically below. It is therefore important to identify basic concepts and set them clearly connected in order to gain comprehension. (Novak & Gowin, as cited in Vallori, 2014). Concept maps help to clarify, define and specify concepts and their relations when beginning a new learning unit and this helps learners to really know what they have to learn from the very beginning.

4. Use of educational resources

   Also, it is important to use educational resources (such as videos, simulations, models) which are related to the concepts to teach. This will promote learning and increase the interest and motivation of students in learning.

5. Teachers should focus teaching on the understanding of abstract concepts and processes rather than memorizing data.

2.8 Summary of Literature Review

The literature reviewed have shown that a lot of researchers (Childs & Sheehan, 2009; Jimoh, 2004; Johnstone, 2006; Ratcliffe, 2002) have identified organic chemistry as one of the most difficult topics in chemistry. Several studies have listed topics such as petroleum, natural and synthetic polymers (Donkoh, 2017; Uchegbu, Ahuchaogu & Amanze, 2017), differentiating of functional groups (Ayalew & Ochonogor, 2015; O'Dwyer & Childs, 2017), benzene (Donkoh, 2017), drawing and representation of organic compounds (Johnstone, 2006; Taber, 2002), isomerism (Taagepera & Noori, 2000), properties of organic compounds (Anderson & Bodner, 2008), aromatic

hydrocarbons (Davis, 2010), and classification of organic compounds (Domin, Al-Masum & Mensah, 2008; Hassan, Hill & Reid, 2004). It was also revealed that factors such as the abstract nature of topics, loaded content with limited time to teach, learners' cognitive abilities, lack of teaching and learning materials, lack of practical work, teachers' inappropriate teaching methods and the inability of teachers to link concepts to the real world are some reasons why students find it difficult to understand the topics and teachers find it difficult to teach some organic chemistry topics.

Added to that, it was also revealed that there is often a mismatch between learners' enthusiasm towards learning chemistry and their teachers' enthusiasm towards teaching it and hence, teaching is not synonymous to learning. This is because what might be easy for the teacher to understand might not be easy for the student to understand due to their differences in experiences and cognitive abilities. It is therefore important that teachers are made aware of their learners' attitudes, preconceptions and perceptions so that they will be able to tailor their instructions to ensure meaningful learning.

CHAPTER THREE

METHODOLOGY

3.0 Overview

This chapter focuses on the research design used to collect data on students' and teachers' perceptions of organic chemistry. The chapter also covers the population, sampling procedure and sample size. It also looks at the research instrument, validity and reliability of the instrument, data collection procedure and data analysis procedure.

3.1 Research Design

This study used the descriptive survey design to find out the perceptions that senior high school chemistry students and teachers in the Asikuma Odoben Brakwa district have about organic chemistry. According to Fraenkel, Wallen and Hyun (2012), a survey collects information from a group of people in order to describe some aspects or characteristics (such as abilities, opinions, attitudes, beliefs, and or knowledge) of the population of which that group is a part of. The main way of collecting information in a survey is through asking questions; the answers to these questions by the subjects constitute the data for the study. Surveys are usually used to collect a large amount of data, for example, questionnaires, test scores, attendance rates, and results of public examinations etc. may be used in surveys, and all of these enable comparisons to be made over time or between groups. In this research a cross sectional survey design in which a sample of a population is studied at a particular point in time was used (Cohen, Manion & Morrison, 2018). This design has the advantages of producing good amount of response from a whole range of people, being less expensive, producing findings more quickly and is more likely to get the

cooperation of respondents since data is collected at only one point in time. This approach made it possible for the researcher to measure the reactions of many respondents to a limited set of questions, and therefore facilitated the comparison and statistical aggregation of the data. In addition, findings related to perceptions are noted to be reliable if data are drawn from a wider and representative sample which is a typical characteristic of a survey design and since this study sought to obtain large data on perceptions of organic chemistry from students and teachers, the researcher found the survey design appropriate for this study.

The survey questionnaire used in this study included both close-ended and open-ended questions. The closed ended questions provided the advantage of generating frequencies of responses that are easy to code and analyse statistically (Oppenheim, 1992 as cited in Cohen et al., 2018) while the open- ended questions gave respondents the opportunity to freely express their honest and personal comments providing information that otherwise might not have been provided by answers to the close-ended questions.

The steps taken in the research are as follows. Firstly, the questionnaires were designed. The items in the questionnaire were focused on perceptions of the topics in the SHS organic chemistry syllabus. Secondly, the questionnaires were piloted and fine-tuned and subsequently used to collect data from students and teachers within a period of three weeks. The data collected was then analyzed and conclusions drawn based on the findings.

3.2 Population

The population of a study is the group that conform to a specific criterion and to which the researcher will like to generalize the result of the study (Fraenkel et al.,

2012). The targeted population for this study were all form three SHS students who studied elective chemistry and their teachers in all the SHS in the Asikuma Odoben Brakwa (AOB) district of the Central region of Ghana. There were 3 senior high schools in the AOB district in the 2018/2019 academic year that offered general science and general agriculture programs with the elective chemistry option. Form three students and their teachers were selected because organic chemistry (chemistry of carbon compounds) forms part of the form three SHS elective chemistry syllabus. The accessible population for this study was all SHS form three students in the AOB district who studied elective chemistry and their teachers. Fraenkel et al. (2012) explain accessible population to be the population to which the researcher is able to generalize findings/ results of the study. The Asikuma Odoben Brakwa district of the central region was chosen because of its proximity and ease of access to the researcher.

3.3 Sample and Sampling Procedure

According to Donnelly and Abdel-Raouf (2016), the sample of a study is a group selected from the population on which information is obtained in a study. In this study the sample was made up of 100 students and 10 teachers (all the chemistry teachers in the schools) from the accessible population.

Sampling is the process of selecting a group of individuals on which information in a study is obtained (Fraenkel et al., 2012). The region (Central region) as well as the district (Asikuma Odoben Brakwa District) were purposively selected due to their proximity and ease of access to the researcher. There are only three government senior high schools in the Asikuma Odoben Brakwa district that offer elective chemistry and therefore these schools were also purposively chosen since the other

schools (private schools) did not offer elective chemistry. For ethical reasons, the three government SHS used for this study are referred to as school A, school B and school C.

Schools A and B offered the general science program while School C did not, but offered general agriculture with an elective chemistry option. The samples for Schools A and B were taken from the form three general science classes while the sample for school C was taken from the form three general agriculture class. School A had three form 3 general science classes, school B had only one form 3 general science class and school C had one form 3 general agriculture class. Simple random sampling (lottery method) was used to select sixty students from the three general science classes in school A. In random sampling, each member of the accessible population has an equal chance of being selected to be part of the sample and the probability of a member of the population being selected is not affected by the selection of other members of the population (Cohen et al., 2018). The following steps were followed in selecting the sixty students from the three form 3 classes using simple random sampling:

1. Names of students were written on sheets of papers and put in a container.
2. The names were then drawn out of the container one after the other until the 60^{th} name.
3. The sixty names drawn out of the container formed the sample of students.

For schools B and C, all the students present in class on the day of data collection formed part of the sample, that is, thirty and ten students respectively. The total number of students in the sample was 100. The chemistry teachers used for this study were purposively selected. Schools A and B had four chemistry teachers each and

school C had only two chemistry teachers. All the chemistry teachers (a total of 10) were selected to be part of the sample.

3.4 Research Instruments

The questionnaire and interview schedules are the most common instruments used in surveys. They are basically the same but only differ in how they are administered. A questionnaire is usually self-administered by the respondent while an interview schedule is usually administered verbally by the researcher or a trained assistant (Fraenkel et al., 2012). In this study, the questionnaire was the main instrument used.

Questionnaire was chosen as the main instrument because it is easy to administer, takes less time to complete, and could be completed at the respondent's own convenience and offers assurance of anonymity. According to Fraenkel et al. (2012), designing one's own instrument is time consuming and not recommended for those without a considerable amount of time, energy and money to invest in it. However, choosing an instrument that has already been developed takes far less time than it does to develop a new instrument to measure the same thing, therefore, selecting an already developed instrument when appropriate, is preferred. Such instruments are usually developed by experts who possess the necessary skills. Based on that assertion, the structure of the questionnaire was adapted from previous studies in the area of organic chemistry perceptions (Davis, 2010; Ayalew & Ochonogor, 2015) and modified to suit this study.

3.4.1 Organic chemistry perception questionnaire for students

The organic chemistry perception questionnaire for students (OCPQS) was used in this survey to secure information from the SHS 3 students on their perception of organic chemistry topics. The OCPQS (Appendix A) was based on the Ministry of

Education (MoE) SHS elective chemistry syllabus and it included both closed ended and open-ended questions. The SHS students' perception instrument had three sections. The first section collected respondents' biographic data. The second section which consisted of 7 items focused on the students' perception of organic chemistry in general. The third section which consisted of 37 items sought to collect data on students' perception of organic chemistry topics. The items numbered 1 to 34 in the third section covered all the topics under organic chemistry in the SHS elective chemistry syllabus. To respond to the items, the respondents were required to indicate their perception of understanding of each of the listed topics on a six (6) point Likert scale. The scales were: very easy to understand, easy to understand, understood only after considerable effort, difficult to understand, very difficult to understand and not taught. Items 35 to 37 solicited free responses on topics that students find most difficult and the reason why they find it difficult as well as suggestions on how organic chemistry can be made meaningful and interesting to students.

3.4.2 Organic chemistry perception questionnaire for teachers

The organic chemistry perception questionnaire for teachers (OCPQT) was used to secure information from the SHS chemistry teachers on their perception of organic chemistry topics. The OCPQT (Appendix B) was based on the MoE SHS elective chemistry syllabus. The OCPQT which was similar to the OCPQS included both closed-ended and open-ended items. The teachers' instrument was also made up of three sections; the first section sought information on teachers' biographic data as well as their educational background and teaching experience. The second section consisting of 5 items sought to find out teachers' perception of organic chemistry in general on a five point Likert scale. The third section consisting of 37 items sought information on teachers' perception of the topics in organic chemistry. To respond to

items 1 to 34, the respondent was required to indicate his or her perception of teaching of each of the listed topics on a five (5) point Likert scale. Thus, 5 was assigned if the respondent had a positive perception toward the topic, that is, if the respondent found the topic very easy to teach; 4 for easy to teach, 3 for not sure, 2 for difficult to teach and 1 was assigned for very difficult to teach. Items 35 – 37 solicited free responses on topics which in teachers' opinion, students have difficulty with and reasons that accounted for the difficulty.

3.4.4 Validity of the instruments

While earlier definitions of validity were based on the view that it was the ability of an instrument to measure what it is designed to measure, a more accurate definition of validity is based on the defensibility of the inferences researchers make from the data collected through the use of the instrument (Cohen et al., 2018; Fraenkel et al., 2012). Expert judgment of senior members in the field of science education was sought on the content and face validities of the instrument. The comments and suggestions from the experts were used in restructuring the items. To ensure the validity of the instrument, the factors that contribute to low validity such as unclear directions, and ambiguities in language were eliminated. The questionnaires were also pilot tested using a sample of thirty randomly selected form 3 general agriculture students from school A. The pilot test was done specifically to help in checking the clarity of the items, give feedback on internal validity of the items and to ensure appropriateness of the data. For example, after the pilot testing, the researcher discovered that the word nomenclature was not familiar to the students so it was replaced with naming. Also, horizontal lines were used to separate the items in the third section (items 1 to 34) of the questionnaire to make it easier for students to tick in line with the statements given.

3.4.5 Reliability of the instrument

Reliability refers to how consistent the scores obtained using an instrument is for each individual; from one administration of the instrument to another and from one set of items to another (Fraenkel et al, 2012). The data from the pilot test were used to test the internal consistency of the questionnaire.

3.5 Data Collection Procedure

An introductory letter was taken from the science department (University of Education, Winneba) to the heads of the selected senior high schools to seek their permission to undertake the study in their schools. The various heads of institutions notified the heads of chemistry departments in the selected schools. Meetings were held with each of the heads of chemistry departments of the schools to arrange a convenient time for the administration of the questionnaire. The heads of chemistry department and chemistry teachers helped the researcher in the selection of respondents prior to the administration of the instrument. The student respondents were put in classrooms and the purpose and relevance of the study were explained to all the respondents involved in the study immediately after the selection of the respondents. Respondents were given the opportunity to opt out if they did not want to be part of the study and also given the opportunity to ask the researcher to clarify issues concerning the study which were not clear to them. The instruments were then administered to the student respondents. In schools A and C, the completed questionnaires were taken on the same day they were administered but in school B, the researcher was asked to come back for the completed questionnaires another day. It took an average of 30 minutes for respondents to complete the questionnaires. The administration of the OCPQT was done in the staff common room. In all cases the

teachers were asked to carefully read through the instructions and the items before responding. In all it took three weeks to collect the data and the return rate was 100%.

3.6 Data Analysis Procedure

The process of making data gathered in a study simpler in order to make it understandable is known as data analysis (Fraenkel et al., 2012). The research questions were used to guide the analysis of the data. That is, the data was analyzed to answer the research questions. The data was organized and various number codes were assigned to each distinctive variable such as age, gender among others for students and also gender, age range, academic qualification among others with respect to teachers. For each item on the questionnaires, code numbers were assigned to the Likert scale. The five point Likert scale in section B of both the OCPQS and OCPQT were collapsed into 3 point scales with 'strongly agree' and 'agree' put together as 'agree' and assigned a number code of 3, 'not sure' was assigned 2, and 'disagree' and 'strongly disagree' were grouped as 'disagree' and assigned a code of 1. For the section C of students' questionnaire, the 6 point Likert scale was collapsed to 4 with 'very easy to understand' and 'easy to understand' put together as 'easy to understand' and 'difficult to understand' and very 'difficult to understand' grouped as 'difficult to understand'. 'Easy to understand' was coded as 4, 'not sure' coded as 3, 'difficult to understand' coded as 2 and 'not taught' was also coded as 1. The 5 point likert scale for section C of the OCPQT was collapsed to 3 with 'very easy to teach' and easy to 'teach' grouped as 'easy to teach' which was assigned a number code of 3, not sure was assigned a number code of 2, while 'difficult to teach' and very 'difficult to teach' were grouped as 'difficult to teach' and assigned a number code of 1.The coded data were statistically analysed using the Statistical Package for the Social Sciences (SPSS) computer software version 20. Data were processed into frequencies and

percentages. This was done to ensure clear description of gender, perception of students and perception of teachers. Tables of frequencies and percentages obtained with the aid of SPSS were used to answer the research questions descriptively.

In addition to that, frequency count (percentages) was also used to discuss students and teachers perception of organic chemistry topics, as well as the open ended questions in both the OCPQS and OCPQT. The details of the data analysis are presented in the next chapter (Chapter four).

CHAPTER FOUR

RESULTS AND DISCUSSION

4.0 Overview

This chapter deals with the presentation and discussion of the results from this study. The results are presented, analysed and discussed based on the research questions.

4.1 Presentation of Results

4.1.1 Background information of respondents

Section A of the Organic Chemistry Perceptions Questionnaire for Students (OCPQS) and Organic Chemistry Perceptions Questionnaire for Teachers (OCPQT) required that respondents indicated their background information. These were collected and analysed in terms of frequencies and percentages and presented in Table 4.1.

Table 4.1: Background Data of Student Respondents

VARIABLE	No. OF STUDENTS	PERCENTAGE
SEX		
MALE	71	71.0
FEMALE	29	29.0
AGE		
15 – 16	5	5.2
17 – 18	54	56.3
19 – 20	25	26.1
21 – 22	9	9.4
23 – 24	3	3.1

Source: Field data, 2019

From Table 4.1, the number of students used for the study was 100 out of which 29 (29.0%) are females and 71 (71.0%) are males. The difference in the numbers of males and females could be because all three schools are mixed schools and the numbers of females reading science subjects in mixed schools are usually lower than males. The ages of the students ranged from a minimum of 15 years to a maximum of 24 years with an average age of 18.46 years and a standard deviation of 1.722.

The teacher respondents' gender, age, academic qualification and number of years in teaching have been summarized into frequencies and percentages and presented in Table 4.2.

Table 4. 2: Relevant Background Information on Teachers

VARIABLE	NUMBER OF TEACHERS	PERCENTAGE
SEX		
MALE	10	100.0
AGE		
23 – 34	1	10.0
35 – 44	5	50.0
45 – 60	4	40.0
ACADEMIC QUALIFICATION		
1ST DEGREE	9	90.0
2ND DEGREE	1	10.0
NUMBER OF YEARS IN TEACHING		
1 -5	5	50.0
6 – 10	2	20.0
11 – 15	1	10.0
16 – 20	2	20.0

Source: Field data, 2019

The information presented in Table 4.2 shows that the teachers have the required certification and competency to teach chemistry at the S.H.S level (at least a first degree in relevant field). Five teachers had been teaching from 1 to 5 years, two had taught from 6 to 10 years, one had taught from 11 to 15 years and two had taught from 16 to 20 years. Fifty percent of the teachers had taught for more than 5 years and therefore would have gathered a lot of experience in teaching.

4.1.2 Analysis of results of students' and teachers' perception of organic chemistry

This section deals with the presentation of results from the analysis of students' and teachers' responses to the items in sections B and C of the OCPQS and OCPQT respectively. The results were collated into frequencies and percentages and presented in tables.

Presented in Table 4.3 is the summary of students' responses on statements in section B of the OCPQS which sought information on students' general perceptions of organic chemistry as a subject. Students were asked to indicate their level of agreement or disagreement to seven statements on a five-point likert scale which sought to seek their general attitudes and perceptions of organic chemistry.

Table 4.3: Students' General Perceptions of Organic Chemistry

No.	STATEMENT	% AG	% UD	% DA
1.	Organic chemistry is a difficult topic for me	45.0	7.0	48.0
2.	It is easy to solve organic chemistry problems	54.0	10.0	36.0
3.	I am very happy during organic chemistry lessons	63.6	7.1	29.3
4.	Organic chemistry concepts are very easy to understand	51.0	7.0	42.0
5.	My chemistry teacher's method of teaching helped me to understand organic chemistry concepts well	58.60	15.10	26.30
6.	Organic chemistry is interesting	64.60	15.10	26.30
7.	I enjoy learning organic chemistry more than the other aspects of chemistry	29.30	11.10	59.60

Source: Field data, 2019

Note: AG- Agree, UD- Undecided, DA- Disagree

The open ended items (items 1-34) in section C of the OCPQS contained a list of topics in the SHS organic chemistry syllabus to which students were required to indicate their perception of difficulty on a six-point Likert scale ranging from easy to understand to very difficult to understand. The six-point Likert scale was collapsed to four points and a summary of the students' responses in the form of frequencies and percentages are presented in Table 4.4.

Table 4.4: Students' Level of Difficulty in Understanding Organic Chemistry Topics

TOPICS	EU (%)	UCE (%)	DU (%)	NT (%)
1. Bonding in carbon	73.0	14.0	12.0	1.0
2. Classification of organic compounds	67.0	17.0	16.0	0.0
3. Identification of elements in organic compounds	56.0	24.0	20.0	0.0
4. Separation and purification of organic compounds.	54.0	21.0	23.0	1.0
5. Sources and characteristics of alkanes	58.0	18.0	23.0	1.0
6. Naming of alkanes and structural isomerism	65.0	18.0	17.0	0.0
7. Preparation, physical and chemical properties of alkanes	53.0	21.0	24.0	2.0
8. Uses of alkanes	72.0	14.0	12.0	1.0
9. Sources and characteristics of alkenes	57.0	22.0	17.0	3.0
10. Naming of alkenes and isomerism in alkenes	55.0	18.0	24.0	1.0
11. Preparation and chemical reactions of alkenes	37.0	24.0	37.0	1.0
12. Uses of alkenes	59.0	19.0	12.0	10.0
13. Sources and characteristic properties of alkynes	48.0	28.0	22.0	2.0
14. Naming of alkynes and isomerism in alkynes	49.0	24.0	25.0	2.0
15. Preparation and chemical reactions of alkynes	30.0	36.0	29.0	5.0
16. Uses of alkynes	61.0	20.0	15.0	4.0
17. The structure and stability of benzene	35.0	26.0	33.0	6.0
18. Reactions of benzene	33.0	28.0	30.0	9.0
19. Comparison of reactions of benzene and alkenes	29.0	32.0	29.0	10.0
20. Preparation and properties of alkanols	48.0	28.0	18.0	6.0
21. Physical properties of alkanols	57.0	26.0	14.0	3.0
22. Naming of alkanols	60.0	20.0	15.0	5.0
23. Primary, Secondary and tertiary alkanols	59.0	18.0	20.0	3.0
24. Chemical reactions of alkanols	46.0	24.0	25.0	5.0
25. Uses of alkanols	68.0	17.0	9.0	6.0
26. Sources, preparation and properties of alkanoic acids	48.0	29.0	18.0	5.0
27. Naming of alkanoic acids	52.0	22.0	23.0	3.0
28. Uses of alkanoic acids	58.0	27.0	12.0	3.0
29. Sources, preparation and properties of alkyl alkanoates	38.0	25.0	30.0	7.0
30. Naming and structure of alkyl alkanoates	48.0	19.0	29.0	4.0
31. Uses of alkyl alkanoates	42.0	23.0	29.0	6.0
32. Soapy and soapless detergents	39.0	23.0	21.0	17.0
33. Polymers and polymerization	33.0	18.0	25.0	24.0
34. Petroleum	22.0	28.0	23.0	27.0

Source: Field data, 2019

Note: EU- Easy to understand, UCE- Understood only after considerable effort, DU- Difficult to understand, NT- Not taught.

Table 4.5 presents students' responses to item 35 in the OCPQS which asked students to list three organic chemistry topics that they found most difficult to understand. These responses have been summarized into frequencies and percentages in Table 4.5.

Table 4.5: List of Students' Difficult Topics

TOPICS	No. OF STUDENTS	PERCENTAGE
1. Polymers and polymerization	69	69.0
2. The structure and stability of benzene	65	65.0
3. Reactions of benzene	60	60.0
4. Naming of alkanes and structural isomerism	56	56.0
5. Petroleum	54	54.0
6. Preparation and chemical reactions of alkynes	12	12.0
7. Sources, preparations and properties of alkyl alkanoates	11	11.0
8. Naming and structure of alkyl alkanoates	9	9.0
9. Soapy and soapless detergents	7	7.0
10. Naming of alkenes and isomerism in alkenes	6	6.0
11. Preparation, physical and chemical properties of alkanes	6	6.0
12. Separation and purification of organic compounds, empirical and molecular formulae	6	6.0
13. Sources and characteristics of alkanes	5	5.0
14. Naming of alkanoic acids	5	5.0
15. Alkanals and alkanones	4	4.0
16. Reactions of amines and amides	4	4.0
17. Identification of elements in organic compounds	3	3.0
18. Naming of alkynes and isomerism in alkynes	3	3.0
19. Comparison of reactions of benzene and alkenes	3	3.0
20. Bonding in carbon	3	3.0
21. Naming of alkanols	3	3.0
22. Preparation and chemical reactions of alkenes	3	3.0
23. Sources and characteristics of alkenes	2	2.0
24. Sources and characteristic properties of alkynes	2	2.0
25. Chemical reactions of alkanols	2	2.0
26. Nomenclature of amines and amides	2	2.0
27. Identification of functional groups	2	2.0
28. Sources, preparation and properties of alkanoic acids	1	1.0
29. Uses of alkyl alkanoates	1	1.0

Source: Field data, 2019

Section B of the OCPQT contained items that sought to find out teachers' general perceptions of organic chemistry. There were five items to which teachers were asked to indicate their level of agreement/disagreement to the statements on a five-point likert scale. The scale was later collapsed to three points and the responses collated into percentages and presented in Table 4.6.

Table 4.6: Teachers' General Perceptions of Organic Chemistry

No.	STATEMENT	AGREE (%)	UNDECIDED (%)	DISAGREE (%)
1.	Organic chemistry is a difficult topic for me to teach	0.0	0.0	100.0
2.	Organic chemistry concepts are very easy to understand	80.0	0.0	20.0
3.	It is easy to solve organic chemistry problems	66.7	0.0	33.3
4.	I enjoy teaching organic chemistry topics more than the other aspects of chemistry	70.0	10.0	20.0
5.	Organic chemistry topics are **not** interesting	10.0	20.0	70.0

Source: Field data, 2019

The closed ended items (items 1-34) in the OCPQT listed topics in the SHS organic chemistry syllabus to which teachers were to indicate the level of difficulty they experienced in teaching on a five-point likert scale which was later collapsed to three points. The responses were then summarized into percentages and presented in Table 4.7.

Table 4.7: Teachers' Perceptions about Difficulty Levels of Organic Chemistry Topics

TOPICS	EASY TO TEACH (%)	NOT SURE (%)	DIFFICULT TO TEACH (%)
1. Bonding in carbon	100.0	0.0	0.0
2. Classification of organic compounds	90.0	10.0	0.0
3. Identification of elements in organic compounds	90.0	0.0	10.0
4. Separation and purification of organic compounds, empirical and molecular formulae	90.0	10.0	0.0
5. Sources and characteristics of alkanes	100.0	0.0	0.0
6. Naming of alkanes and structural isomerism	90.0	10.0	0.0
7. Preparation and properties of alkanes	70.0	0.0	30.0
8. Uses of alkanes	90.0	0.0	10.0
9. Sources and characteristics of alkenes	80.0	0.0	20.0
10. Naming of alkenes and isomerism in alkenes	90.0	0.0	10.0
11. Preparation and chemical reactions of alkenes	70.0	0.0	30.0
12. Uses of alkenes	90.0	0.0	10.0
13. Sources and characteristic properties of alkynes	80.0	10.0	10.0
14. Naming of alkynes and isomerism	90.0	0.0	10.0
15. Preparation and chemical reactions of alkynes	60.0	0.0	40.0
16. Uses of alkynes	80.0	10.0	10.0
17. The structure and stability of benzene	60.0	0.0	40.0
18. Reactions of benzene	50.0	0.0	50.0
19. Comparison of reactions of benzene and alkenes	60.0	0.0	40.0
20. Preparation and properties of alkanols	100.0	0.0	0.0
21. Physical properties of alkanols	100.0	0.0	0.0
22. Naming of alkanols	90.0	10.0	0.0
23. Primary, Secondary and tertiary alkanols	90.0	0.0	10.0
24. Chemical reactions of alkanols	80.0	0.0	20.0
25. Uses of alkanols	100.0	0.0	0.0
26. Sources and properties of alkanoic acids	90.0	0.0	10.0
27. Naming of alkanoic acids	100.0	0.0	0.0
28. Uses of alkanoic acids	100.0	0.0	0.0
29. Sources and properties of alkyl alkanoates	80.0	10.0	10.0
30. Naming and structure of alkyl alkanoates	90.0	0.0	10.0
31. Uses of alkyl alkanoates	90.0	0.0	10.0
32. Soapy and soapless detergents	80.0	0.0	20.0
33. Polymers and polymerization	50.0	10.0	40.0
34. Petroleum	70.0	0.0	30.0

Source: Field data, 2019

Teachers were also asked in section C of the OCPQT (item 35) to list three organic chemistry topics that they perceived to be most difficult for their students to understand. The responses to this item were summarized and presented in Table 4.8

Table 4.8: Topics that Teachers Perceived to be Difficult for Students

TOPIC	NUMBER OF TEACHERS	PERCENTAGE
Petroleum	4	40.0
Polymers and polymerization	4	40.0
Reactions of alkanes	4	40.0
Reactions of alkenes	3	30.0
Structure and stability of benzene	2	20.0
Reactions of benzene	2	20.0
Reactions of alkynes	1	10.0
Classification of organic compounds	1	10.0
Reactions of alkyl alkanoates	1	10.0
Alkanoic acids	1	10.0
Chemical reactions of the various functional groups	1	10.0
Reactions of alkanols	1	10.0
Nomenclature	2	20.0
Primary , secondary and tertiary alkanols	1	10.0
Soapy and soapless detergents	1	10.0

Source: Field data, 2019

Research question four sought to find out the differences and similarities between students' difficult topics and topics perceived to be difficult to them by their teachers. These topics which have already been listed in Table 4.5 and Table 4.8 have been compiled and compared in Table 4.9.

Table 4.9: Comparison of Students' Difficult Topics and Topics Perceived by Teachers to be Difficult for Students

TOPICS	STUDENTS (%)	TEACHERS (%)
Polymers and polymerization	69.0	40.0
The structure and stability of benzene	65.0	20.0
Reactions of benzene	60.0	20.0
Naming of alkanes and structural isomerism	56.0	Not listed
Petroleum	54.0	40.0
Preparation, physical and chemical properties of alkanes	7.0	40.0
Preparation and chemical reactions of alkenes	3.0	30.0
Preparation and chemical reactions of alkynes	12.0	20.0
Nomenclature	Not listed	20.0
Bonding in carbon	3.0	Not listed
Identification of elements in organic compounds	5.0	Not listed
Separation and purification of organic compounds, empirical and molecular formulae	6.0	10.0
Sources and characteristics of alkanes	6.0	Not listed
Sources and characteristics of alkenes	2.0	Not listed
Naming of alkenes and isomerism in alkenes	9.0	Not listed
Sources and characteristic properties of alkynes	2.0	Not listed
Naming of alkynes and isomerism in alkynes	4.0	Not listed
Comparison of reactions of benzene and alkenes	4.0	Not listed
Naming of alkanols	3.0	Not listed
Chemical reactions of alkanols	2.0	10.0
Alkanoic acids	7.0	10.0
Reactions of alkyl alkanoates	Not listed	10.0
Sources, preparation and properties of alkyl alkanoates	11.0	Not listed
Naming and structure of alkyl alkanoates	9.0	Not listed
Uses of alkyl alkanoates	1.0	Not listed
Soapy and soapless detergents	9.0	10.0
Nomenclature of amines and amides	2.0	Not listed
Reactions of amines and amides	5.0	Not listed
Alkanals and alkanones	6.0	Not listed
Identification of functional groups	2.0	Not listed
Primary, secondary and tertiary alkanols	Not listed	10.0
Classification of organic compounds	Not listed	10.0
Chemical reactions of various functional groups	Not listed	10.0

Source: Field data, 2019

4.2 Discussion of Results

The results presented above are discussed below using the research questions to guide the discussions.

4.2.1 Research question 1: What are the SHS students' and teachers' perceptions of organic chemistry?

Part B of the OCPQS contained items that sought to elicit responses about students' general perception of organic chemistry on a likert scale. The five point scale was collapsed to three with 'strongly agree' and 'agree' grouped as 'agree' and 'strongly disagree' and 'disagree' grouped as disagree. From Table 4.3, it can be seen that a considerable number of students (45) representing 45.0% of the student sample agreed that organic chemistry is a difficult subject for them while 48 students (48.0%) disagreed. Although a simple majority disagreed that organic chemistry is difficult, the difference between the number of students who agreed and those who disagreed is not large so it can be inferred that almost half of the student sample see organic chemistry as difficult while the other half see if as not difficult. This is in contrast to findings from a study on Irish high school learners and teachers' perceptions and perspectives of organic chemistry by O'Dwyer and Childs (2017) which revealed that less than one third (75, 27.5%) of the high school learners they studied found organic chemistry easy while 165 (59.8%) of the learners found organic chemistry difficult to learn. About 51% of the students agreed that organic chemistry concepts are very easy to understand, 54% find it easy to solve organic chemistry problems, 63% are happy during organic chemistry lessons, 58% agreed that their chemistry teacher's method of teaching helped them to understand organic chemistry concepts well and 64% found organic chemistry interesting. However, 59% disagreed with the statement 'I enjoy learning organic chemistry more than the other aspects of elective chemistry'

while only 29% agreed to it. It could be inferred that if given the choice, majority (59%) of these students would choose to read the other aspects of chemistry over organic chemistry. Generally, it can be said that students have a fairly positive perception of organic chemistry and a positive attitude towards it but would not choose to study organic chemistry over the other aspects of chemistry if given the chance.

To seek information on teachers' general perceptions of organic chemistry, section B of the OCPQT contained 5 statements to which teachers were to indicate their level of agreement or disagreement to the statements on a five point likert scale. The 5 point scale was collapsed to 3 with 'strongly agree' and 'agree' put together as 'agree' and 'strongly disagree' and 'disagree' grouped as 'disagree' and the results presented as percentages in Table 4.6. From Table 4.6, it can be seen that all the teachers (100%) disagreed with the statement 'organic chemistry is a difficult subject for me' meaning that all the teachers viewed organic chemistry as an easy subject. Eight of the teachers (representing 80%) agreed that organic chemistry concepts are very easy to understand while 2 of them (20%) disagreed with this statement. Six teachers agreed that it is easy to solve organic chemistry problems, 3 disagreed and 1 teacher did not respond to the statement. Seven of the teachers enjoyed teaching organic chemistry topics more than the other aspects of chemistry while 2 of them did not enjoy teaching organic chemistry more than the other aspects of chemistry. When the teachers' response to this particular statement is compared with that of the students, there seems to be a mismatch between the enthusiasm of teachers about organic chemistry and that of their students. This mismatch could be attributed to the fact that teachers are 'experts' while learners are just beginners in organic chemistry. Also, 7 teachers

disagreed to the statement 'organic chemistry topics are not interesting' while 1 agreed.

Unlike the students who perceived organic chemistry as interesting but would choose the other aspects of chemistry over organic chemistry, the teachers perceived organic chemistry as easy and interesting and would choose to teach organic chemistry over the other aspects of chemistry.

4.2.2: Research question 2: Which topics in organic chemistry do students and teachers perceive to be difficult or easy?

Section C of the OCPQS listed all the 34 topics in the SHS organic chemistry syllabus and students were asked to indicate how easy or difficult it was to understand the topics on a six point likert scale. Before analysis, the 6 point likert scale was collapsed to 4 with 'very easy to understand' and 'easy to understand' put together as 'easy to understand' and 'difficult to understand' and very 'difficult to understand' grouped as 'difficult to understand'. From the summary of responses presented in Table 4.4, all the topics listed were viewed by majority of students as easy to understand except preparation and chemical reactions of alkenes, preparation and chemical reactions of alkynes, structure and stability of benzene, reactions of benzene, comparison of reactions of benzene and alkenes.

Preparation and chemical reactions of alkenes was chosen by 37% of students as difficult and the same percentage of students (37%) also choose it as easy to understand. However, 24% of students asserted that they understood it only after considerable effort. If something can only be understood after considerable effort, then it poses some level of difficulty and could be said to be fairly difficult. In view of this it can be concluded that preparation and chemical reactions of alkenes is

perceived as difficult by the SHS students. Different reasons could be attributed to the difficulties students face in studying. It could be a teacher factor (teachers' methodologies, punctuality and attendance to class, mastery of content and ability to deliver effectively), students' factor (students' attitude to learning, motivation, attendance to class, paying attention in class), and lack of teaching and learning materials or due to an extrinsic difficulty; difficulty associated with the subject itself beyond the control of the learner (Millar, 1991 as cited in O'Dwyer & Childs, 2017).

Comparison of the reactions of benzene and alkenes also had the same percentage (29%) of students choosing 'easy to understand' and 'difficult to understand' respectively while a greater percentage (32%) understood it only after considerable effort. As stated earlier, the fact that considerable effort had to be put in before understanding could take place means that some level of difficulty had to be overcome, and therefore, the topic 'comparison of the reactions of benzene and alkenes' can be said to be difficult to understand by the SHS students.

The topics 'preparation and chemical reactions of alkynes', 'structure and stability of benzene' and 'reactions of benzene' recorded a slightly higher percentage of students viewing them as easy to understand (30%, 35% and 33% respectively) than those that view these topics as difficult to understand (29%, 33% and 30% respectively). However, an equally appreciable percentage of students (36%, 26% and 28% respectively) also viewed these topics as 'understood only after considerable effort'. Conclusions could therefore be drawn that these topics are perceived to be difficult by the SHS students.

In addition, petroleum was viewed by 23% of students to be difficult to understand, 22% of students saw it as easy to understand and 23% saw it as a topic that could be

understood only after considerable effort. This topic also recorded the highest percentage of students (27%) responding to it as 'not taught'. Students' difficulties in understanding petroleum could therefore be attributed to the probability that it was not taught or the other reasons stated earlier. Seeing that almost the same percentage of students that find petroleum difficult to understand also chose 'not taught', it could be that indeed most teachers did not teach petroleum due to the fact that petroleum is the last topic under organic chemistry in the SHS chemistry syllabus and so could not get to the topic because of time constraints. Another reason could be that the students were not present in class when petroleum was taught or it was taught during extra classes where some of the students were not present. Polymers and polymerization also had quite a large percentage of students (25%) viewing it as difficult to understand and the second highest percentage of students saying it was not taught (24%). This could mean that indeed the topic was not taught to these students or the students were not in class the day the topic was taught.

Furthermore, students were required to list three most difficult topics in organic chemistry in item 35 of the OCPQS. The responses have been collated into percentages and presented in Table 4.5. From Table 4.5, the top 5 most difficult topics for students and their percentages are: polymers and polymerization (69%), structure and stability of benzene (65%), reactions of benzene (60%), naming of alkanes and structural isomerism (56%) and petroleum (54%). Comparing the difficult topics stated in Tables 4.4 and 4.5, it could be seen that structure and stability of benzene, reactions of benzene and petroleum appear in both tables and therefore it could be said that they are the top three most difficult to understand topics chosen by the students. Although polymers and polymerization and naming of alkanes and structural isomerism were not chosen by majority of students as difficult to understand in Table

4.4, they were stated by a large number of students in Table 4.5. In similar research works (Davis, 2010; Ayalew & Ochonogor, 2015; O'Dwyer & Childs, 2017; Uchegbu, Ahuchaogu & Amanze, 2017), petroleum, benzene and synthetic polymers were also identified as topics that were difficult for students to understand.

The responses to the close ended items in section C of the OCPQT which sought to find out the difficult/easy topics for teachers were analysed as percentages and presented in Table 4.7. The 5 point likert scale was collapsed to 3 with 'very easy to teach' and easy to 'teach' grouped as 'easy to teach' while 'difficult to teach' and very 'difficult to teach' were grouped as 'difficult to teach'. It can be seen from Table 4.7 that teachers generally perceived all organic chemistry topics as easy to teach with the exception of reactions of benzene. This agrees with findings from Donkoh (2017) who also stated that chemistry teachers perceived none of the SHS organic chemistry topics as difficult to teach. It is however important to note that the fact that teachers rate a topic as easy to teach does not mean it is best taught (taught well) neither does a teacher rating a topic as difficult to teach make that topic the most poorly taught topic (not well taught) as these results are only representative of the teachers' attitudes (O'Dwyer & Childs, 2017). This means that a topic could be rated as easiest to teach by teachers but may end up not being well taught and a topic rated most difficult to teach might end up being well taught by the teacher. The teachers may be able to teach these topics to the understanding of their students or not. The few topics which recorded an appreciable number of teachers viewing them as difficult to teach are discussed below. Attention was paid to topics which at least four out of the ten teachers viewed as difficult to teach. The following topics were perceived as difficult to teach by at least 40% of the teachers: preparation and chemical reactions of alkynes (40%), the structure and stability of benzene (40%), reactions of benzene (50%),

comparison of reactions of benzene and alkenes (40%), and polymers and polymerization (40%). A lot of factors could contribute to a teacher's difficulty in teaching a particular topic. Some of the factors may be the extensive nature of the content (loaded content), high cognitive demand of the content, lack of teaching and learning materials like textbooks, laboratory equipment and lack of mastery over the content by the teacher.

In conclusion, the organic chemistry topics which were perceived as difficult by the SHS students are preparation and chemical reactions of alkenes, preparation and chemical reactions of alkynes, structure and stability of benzene, reactions of benzene, comparison of reactions of benzene and alkenes, petroleum, polymers and naming of alkanes and structural isomerism. The rest of the organic chemistry topics in the SHS chemistry syllabus were perceived as easy to understand. In addition, out of all the organic chemistry topics listed, only reactions of benzene was rated by equal percentage of teachers as easy to teach and difficult to teach. This means that half of the teachers viewed it as easy to teach while the other half viewed it as difficult to teach. It can therefore be concluded that reactions of benzene poses the same level of difficulty to teachers as the level of easiness it poses.

4.2.2.1 Reasons students gave for student difficulties in understanding organic chemistry topics

Some reasons given by students for the difficulties as required by item 36 of the OCPQS could be grouped into teacher factors, student factors, lack of teaching and learning materials and difficulties related to the nature of the topics themselves. Several researchers (Davis, 2010; Ayalew & Ochonogor, 2015; O'Dwyer & Childs, 2017; Uchegbu, Ahuchaogu & Amanze, 2017) have stated similar reasons for

students' difficulties in understanding organic chemistry topics. These factors are discussed below.

1. Teacher factors

   Some of the students attributed their difficulty in understanding the topics to the teaching methods of their teachers. While some complained that the teachers rushed through lessons, others said teachers only used the lecture method to teach without any practical work. It is important to note that a teacher's ability to explain concepts well using appropriate methods goes a long way to enhance students' understanding. Some students also asserted that there was lack of teachers to handle organic chemistry. It could be that these students did not have enough chemistry teachers in their school and therefore could not get teachers to teach them the organic chemistry topics. Teachers not teaching into details, teachers not teaching all topics and teachers giving explanations which are different from what is in textbooks are some other reasons that students gave for their difficulty in understanding organic chemistry topics.

2. Student factors

   Some students asserted that their lack of interest in studying organic chemistry accounted for their difficulty in understanding organic chemistry topics. According to Omiko (2017), there is a relationship between the students' interests and the topics they considered difficult. This means that if a student does not have interest in a particular subject, they will not pay attention to that subject and will therefore find it difficult understanding the subject. Also, students' attitudes towards learning organic chemistry could also be a contributing factor for the difficulties they face in understanding the

topics. For example, some students simply gave their reason for finding organic chemistry topics difficult as "laziness", "I did not love studying chemistry at junior high school so I hate reading chemistry", "I did not put much effort into reading and researching". With these negative attitudes towards learning, it is not surprising that some students find some organic chemistry topics difficult since the effort you put into studying usually determines your level of understanding and performance.

3. Lack of teaching and learning materials

One major challenge identified by most of the students was the lack of textbooks with organic chemistry content. Although there is abundance of SHS chemistry textbooks on the market, students claimed the prices of these books were so high that they could not afford to buy them. Under the current free SHS policy of the government of Ghana, students are supplied with free textbooks for the core subjects while the textbooks for elective subjects are to be bought by students (or parents). Some of these textbooks could however be found at the schools' reference libraries but the quantities are not enough for all students to get access to them. This means that if a parent or student cannot afford to buy an elective textbook, the student will have to almost solely rely on notes given by teachers in class which might not be detailed enough. Also, out of the three schools used for this study, only one of them had a well-resourced science laboratory. The rest of the schools had some makeshift laboratories with inadequate laboratory equipment. The lack of laboratory facilities and equipment hinders practical lessons which contributes to difficulty in understanding on the part of students, especially, if the topic requires practical or demonstrations.

4. Difficulty related with the nature of organic chemistry topics

   Reasons for difficulty given by students which are "intrinsic" to the topics include abstract nature of the topics, complexity and having a lot of principles pushing students to do rote memorization, too many reactions making it difficult to remember them all. Similar reasons for students' difficulty was also given by Ayalew and Ochonogor (2015). Organic chemistry places a high cognitive demand on students (Ingle & Shayer as cited in O'Dwyer & Childs, 2017). The abstract concepts of chemistry require thinking on the macroscopic (tangible and visible), submicroscopic (molecular and invisible) and symbolic (chemical symbols and equations). To be able to do logical and abstract thinking, students need to be operating at the formal operational stage of Piaget's model of cognitive development. However research has shown that only a small number of students at high school level operate at this level. The fact that some students stated the abstract nature of topics as a source of difficulty could mean that these students have not developed the cognitive ability to do abstract thinking (are not at the formal operational stage).

4.2.3 Research question 3: Which topic(s) in organic chemistry do teachers perceive to be difficult for their students?

Teachers were asked to indicate three topics that they perceived to be most difficult for their students to understand in the open ended part of section C of the OCPQT. The summarized results in Table 4.8 show that polymers and polymerization (40%), petroleum (40%), reactions of alkanes (40%) and reactions of alkenes (30%) were the top four topics that teachers perceived to be most difficult for their students. However, structure and stability of benzene, separation and purification of compounds, classification of organic compounds, reactions of benzene, reactions of alkyl

alkanoates, alkanoic acids, chemical reactions of the various organic compounds, reactions of alkynes, reactions of alkanols, nomenclature, primary, secondary and tertiary alkanols, soapy and soapless detergents were also listed by a few teachers as difficult for students to understand. Different reasons were given by teachers for these difficulties. Some of the reasons given are explained below.

1. Curriculum and content difficulties

   Teachers asserted that the organic chemistry topics are quite abstract and very difficult to practicalize and link them to real life situations. Content overload and limited time for teaching was also another contributing factor that teachers stated. In a research by O'Dwyer and Childs (2017) in Ireland, high school and university teachers also mentioned similar reasons such as content overload and vague description, the multi-dimensional and abstract nature of the subject as factors that contributed to students' difficulties in understanding organic chemistry topics. Teachers also asserted that although the organic chemistry content was loaded, the time allocated for teaching was limited and not enough. This assertion was also reechoed by students who also claimed that the organic chemistry content was loaded with limited time given for teaching it.

2. Learner factors

   Teachers claimed that the main difficulty that students faced in understanding reactions of benzene was that students found it difficult understanding the concept of delocalization of electrons. Another reason given by teachers for students' difficulty in the topics they perceived to be difficult for them was that the students were unable to make use of relevant previous knowledge. This may most likely be due to the fact that students did not have the cognitive

ability to process those concepts or did not understand the introductory topics (relevant previous knowledge) like identifying functional groups which are supposed to form the foundation for the rest of the organic chemistry topics. Actually some of the teachers claimed that the similarities between some of the functional groups confused the students. For example, if a student is not able to identify the functional group to which a substance belongs to, they may not be able to predict how that substance will react with given reagents. This is because every functional group has their characteristic reactions that they undergo. To the teacher, the student was not able to apply previous knowledge but it may turn out that the student did not have/ understand the previous knowledge in the first place to be able to even apply it. This assertion was confirmed by O'Dwyer and Childs (2017) who observed that many teachers had recognized the high cognitive demand of organic reactions, mechanisms and synthesis and remarked that these topics involved the integration of all that the pupils have learned in organic chemistry. According to the teachers in that study, their students attempted to learn reactions and mechanisms by rote memorization because they had no understanding of the functional groups and transfer of electrons and other introductory topics and could not comprehend the abstract concepts.

3. Lack of teaching and learning materials

Another reason that teachers cited for their students' difficulties in organic chemistry topics was the lack of teaching and learning materials like molecular models, simulation software and videos for practical demonstrations. As stated earlier, only one of the three schools used in this study had well equipped science laboratories and this could only mean that the

teachers in the other schools would have to use improvised laboratories and materials.

4.2.4 Research question 4: What are the differences and similarities between students' difficulty areas (topics) and the areas perceived to be difficult for them by teachers?

Research question 5 sought to find out if students' difficult topics are the same as the topics teachers perceive to be difficult for their students. One open-ended item in the OCPQS asked students to list 3 topics that they found most difficult to understand in organic chemistry and another open-ended item in the OCPQT asked teachers to list 3 topics that they perceived to be most difficult for their students. The responses to these items were compiled into percentages and compared in Table 4.9. Two of the topics that were listed by most students, polymers and polymerization (69% of students) and petroleum (54% of students) were also listed by teachers (4, 40%) as difficult for students. However, naming of alkanes and structural isomerism which was listed by 56 students (56%) as difficult was not stated by any teacher as difficult for their students. In addition, reactions of benzene which was listed by 60 (60%) students and structure and stability of benzene which was listed by 65 (65%) students was listed by only 2 (20%) teachers as a difficult topic for students. Some topics which were listed by teachers as difficult for students to understand were either not listed at all or listed by just a few students as difficult for them. For instance, preparation, physical and chemical properties of alkanes which was stated by 4 out of the 10 teachers as difficult for their students was listed by only 7 students (7%) as difficult. This comparison is necessary because often times topics that students find difficult to understand might not be the same topics that teachers assume to be difficult for the students. According to Johnstone (2000) topics/concepts that may be

logical and simple to the chemistry teacher may not be so for the student. For understanding to take place in learners, there is the need for teachers to have an accurate awareness of their students' prior knowledge, misconceptions, level of cognitive development, opinions and attitudes. This will enable teachers to better adapt their lessons to facilitate a deeper and more holistic understanding of the subject.

The reasons given by both students and teachers were similar. Both groups of respondents cited abstract nature of content, student related factors, overloaded content with limited time for teaching and learning, lack of teaching and learning materials. Although students also blamed their difficulty on teachers' teaching methods and attitudes, teachers did not blame themselves for their students' difficulties. These reasons for students' difficulty are in line with a statement made by Woldeamanuel, Atagana and Engida (2014) in a research on "what makes chemistry difficult" in South Africa. They found that many researchers, teachers and science educators regard chemistry in general as a difficult subject for students because of the abstract nature of many chemical concepts, teaching styles applied in class, lack of teaching aids and the difficulty of the language of chemistry. Tilahun and Tirfu (2016) in their study on common difficulties experienced by grade 12 students in a private school in Ethiopia agreed that the reason for students' difficulty in chemistry could be attributed to absence of laboratory works, absence of teaching and learning resources, poor teaching and learning strategies as well as poor English language skills.

From Table 4.9 and the discussion above, it can be concluded that although there were a few differences in the topics perceived by teachers to be difficult for their students

and the topics that students themselves listed as difficult to understand, the teachers were able to give a fairly accurate prediction of their students difficult topics.

4.2.5 Recommendations from students and teachers for making organic chemistry in senior high schools meaningful and interesting

An open ended item in section C of both the OCPQT and OCPQS asked respondents to write what they thought should be done to make teaching and learning of SHS organic chemistry more meaningful and interesting. The responses to these items have been discussed below.

1. Using varied teaching methodologies

   Many teachers and students recommended that instead of teachers using only the lecture method in teaching organic chemistry, teachers should look at using more of demonstrations, practical work in the laboratory, letting students use molecular models, computer simulations and using audio visuals in their teaching. These methods when used, will facilitate students' understanding of concepts and help them remember what has been taught better than if only the lecture method is used. Chiu (2005) and Okwuduba, Offiah and Madichie (2018) have confirmed that conducting experimental activities and using computer simulations to teach help in developing positive students' attitudes in learning chemistry and enhancing achievement in chemistry. Practical work needs to essentially be about stimulating and challenging students to think and understand the relation between evidence and theory (Yunus & Ali, 2013) and students who learn by these inquiry approaches are responsible for developing their own answers to questions rather than exclusively relying on the teacher and or textbooks (Klopfer, Aikenhead & Robinsen, 2001).

2. Provision of more textbooks

   Participants suggested that more elective chemistry textbooks with content on organic chemistry be provided to students. This would ensure that students would have easy access to textbooks and will not have to depend only on the notes given to them by teachers. Students can then read wider on topics and get exposed to more examples than what is given in class. This may go a long way to help students especially if they are able to read ahead before going to class to understand what is taught in class better.

3. Solving of more examples and prompt feedback

   Students suggested that teachers should solve more problems on organic chemistry with them in class rather than just giving of notes and explanations. In solving examples in class, students are exposed to possible examination questions and also learn how to solve problems/ answer organic chemistry questions. Students also suggested that whenever assignments are given, teachers should do well to provide prompt feedback. This would help students see how they are performing, see their mistakes and correct them with the help of teachers.

4. Adapting content to students' cognitive abilities and use of appropriate language level

   What may be easy for teachers to understand may not be easy for students to understand because of their differences in cognitive abilities. Although the content of the chemistry curriculum has been designed with students' age and cognitive abilities in mind, it is important that in explaining concepts, teachers adapt the content to suit their students cognitive ability and to the understanding of the average student. The students in this study suggested that

their teachers should teach so that the average performing students in the class understand. Also, with English language as the medium of instruction and chemistry having its own language, students suggested that if possible, teachers should break down the "scientific" language to their level of understanding, preferably in the local language.

5. Relating content to real world situations

   Many students stated that they could not see the link between what they are being taught in class and the real world situations and would appreciate the subject better if they could see the application to real world situations. As much as possible, teachers should try and point out real life applications of what they teach to students. In view of this both teachers and students suggested that field trips to chemical industries, especially, those that deal with the application of organic chemistry like soap production companies, oil refineries, etc. be organized.

6. Duration of tuition of content

   Teachers and students were also of the view that because of the extensive content of the SHS organic chemistry topics, the teaching and learning of organic chemistry should be spread throughout the three year duration of senior high school rather than teaching it in SHS 3 as stipulated in the SHS chemistry syllabus. Some were even of the view that if possible, organic chemistry should be separated from the other aspects of chemistry in the SHS curriculum and treated as a subject on its own due to its loaded content.

7. Time of day for teaching organic chemistry

   Students suggested that chemistry should be taught in the morning when their minds are well rested and fresh rather than in the afternoons when they might

be exhausted because of the high cognitive demand the subject places on them.

Similar suggestions were given by teachers and students in a study by Tilahun and Tirfu (2016) who also suggested the provision of more teaching and learning aids, more practical activities, improvement in assessment, use of appropriate English language by teachers and paying attention to more challenging topics as ways of improving students' learning in chemistry.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.0 Overview

The chapter includes the summary of the findings, conclusions drawn from the study, and recommendations based on the findings.

5.1 Summary of Work

The purpose of this study was to investigate SHS teachers' and students' perceptions of organic chemistry, find out students' difficult topics as well as topics that teachers perceive to be difficult for students and compare students' difficult topics to topics that their teachers perceive to be difficult for them. Questionnaires with closed ended and open ended items were given to both students and teachers. Responses to the questionnaires were put into SPSS version 20 software and analyzed using descriptive statistics (frequencies and percentages). The results were then presented in tables and discussed.

5.2 Key Findings

The following are key findings from this study.

- Students have a fair positive perception of organic chemistry but would not choose to study organic chemistry if given the chance. Forty-five percent of the student sample agreed that organic chemistry is a difficult subject for them while 48 students (48.0%) disagreed. About, 51% of the students agreed that organic chemistry concepts were very easy to understand, 54% found it easy to solve organic chemistry problems, 63% were happy during organic chemistry lessons, 58% agreed that their chemistry teacher's method of teaching helped

them to understand organic chemistry concepts well and 64% found organic chemistry interesting. However, 59% disagreed with the statement 'I enjoy learning organic chemistry more than the other aspects of elective chemistry' while only 29% agreed to it. This means that the students did not perceive chemistry to be difficult but enjoy learning the other aspects of chemistry more than organic chemistry.

- The organic chemistry topics which were perceived as difficult by the SHS students were preparation and chemical reactions of alkenes, preparation and chemical reactions of alkynes, structure and stability of benzene, reactions of benzene, comparison of reactions of benzene and alkenes, petroleum, polymers and naming of alkanes and structural isomerism. The rest of the organic chemistry topics (26 out of the 34 topics) in the SHS chemistry syllabus were perceived as easy to understand. Some reasons given by students for these difficulties were teaching methods of teachers, students' cognitive abilities, students' attitudes towards learning, lack of teaching and learning materials such as textbooks, laboratory facilities and apparatus as well as difficulties associated with the topics themselves like abstract nature of topics, content overload and limited time for teaching content.
- Unlike the students who perceived organic chemistry as interesting but would choose the other aspects of chemistry over organic chemistry, the teachers perceived organic chemistry as easy and interesting and would choose to teach organic chemistry over the other aspects of chemistry. Furthermore, the teachers perceived 33 out of the 34 SHS organic chemistry topics as easy to teach. It was only reactions of benzene that 50% of the teachers perceived as easy to teach while the other 50% perceived it as difficult to teach. It is no

wonder that reactions of benzene were one of the topics students listed as difficult to understand.

- Polymers and polymerization, petroleum, reactions of alkanes and reactions of alkenes were the top four topics that teachers perceived to be most difficult for their students. The teachers also cited the abstract nature of the topics, the high cognitive demand of the topics, loaded content with limited time to teach, students' inability to apply relevant previous knowledge and lack of teaching and learning materials as reasons why the above mentioned topics being difficult for students.
- Although there were a few differences in the topics perceived by teachers to be difficult for their students and the topics that students themselves listed as difficult to understand, the teachers were able to give a fairly accurate prediction of their students' difficult topics. Polymers and polymerization and petroleum were listed by both students and teachers as difficult for students to understand; structure and stability of benzene and reactions of benzene were listed as difficult to understand by many students but listed by a few teachers (20%) as difficult for their students; naming of alkanes and structural isomerism was listed by 60% of students as difficult to understand but was not listed by teachers as a difficult topic for their students; Preparation, physical and chemical properties of alkanes was listed by teachers as difficult for students by teachers but was listed by only a few students (7 students) as difficult to understand.

5.3 Conclusions

This study was aimed at finding the differential perceptions of selected SHS teachers and students. The study specifically considered the general perceptions of students

and teachers in senior high schools in Asikuma Odoben Brakwa district about organic chemistry, the topics that students and teachers considered easy or difficult to understand and teach (for teachers), and also compared the students' difficult topics to the topics that teachers perceived to be difficult for students.

Findings revealed that the SHS teachers had a positive perception of organic chemistry and found 33 out of the 34 organic chemistry topics in the SHS chemistry syllabus easy to teach. Reactions of benzene of benzene was the only topic that 50% of the teachers found easy to teach while the other 50% found it difficult to teach. The students on the other hand also had a positive perception and positive attitude towards organic chemistry but would be interested in studying the other aspects of chemistry rather than organic chemistry. Students found 26 out of the 34 organic chemistry topics easy to understand. The topics that the students perceived to be difficult to understand are: preparation and chemical reactions of alkenes, preparation and chemical reactions of alkynes, structure and stability of benzene, reactions of benzene, comparison of reactions of benzene and alkenes, petroleum, polymers and naming of alkanes and structural isomerism). Their SHS teachers also perceived polymers and polymerization, petroleum, reactions of alkanes and reactions of alkenes to be difficult for their students to understand. Both students and teachers identified the overloaded content of the SHS organic chemistry topics, limited time to teach, abstract nature of organic chemistry concepts, lack of teaching and learning materials such as textbooks, molecular models, videos on topics, laboratory facilities as possible contributors to the students' and teachers' difficulties. The students also cited teachers' methods of teaching (especially the traditional talk and chalk method of teaching) as one of the factors that contributed to their difficulties in understanding the above listed topics. Suggestions on how to make the teaching and learning of organic chemistry at the

SHS level interesting and more meaningful were also given by the students and teachers. These suggestions are included in the recommendations for making the teaching and learning of organic chemistry more interesting and understandable.

5.4 Recommendations

Considering the findings and conclusions drawn from the study, the following recommendations have been made for consideration.

- Since students cited their teachers' methods of teaching as a contributing factor to their difficulty in understanding organic chemistry topics, it is recommended that SHS chemistry teachers in the Asikuma Odoben Brakwa District should vary their teaching methodologies and include more student-oriented methodologies like discussions, using molecular models, using computer simulations and videos to teach. All these methods have been proven by research to enhance students' understanding in various concepts. Heads of senior high schools can from time to time organize in service trainings and workshops for their teachers on innovative ways of teaching organic chemistry. This will go a long way to help teachers to teach better.
- Another area of concern that came up from findings of this study was that due to the content overload of organic chemistry topics and the limited time available to teach, many teachers teach the organic chemistry aspect of SHS chemistry in the last semester/term of the third year and therefore either skip some aspects or just rush through the topics. It is recommended that SHS teachers in the Asikuma Odoben Brakwa district should start teaching organic chemistry earlier, if possible from the first year so that they can get time to cover all topics.

- Chemistry teachers in the Asikuma Odoben Brakwa district should also pay more attention to the topics selected by students as difficult to understand during organic chemistry lessons.

5.5 Suggestions

- More field trips to chemical industries that use the application of organic chemistry to produce goods and services should be embarked on by students and teachers. This will help both teachers and students to link the theoretical aspect of what they do in the classroom to what is done in the industries or real world. This will make organic chemistry more meaningful and relatable to them.
- Considering the cognitive demand that organic chemistry places on students and the time it is taught in school, it is suggested that the heads of chemistry departments liaise with time table planners in the various schools to fix chemistry lessons at times where students would have had enough rest and not when they are already exhausted from learning other subjects.
- Textbooks and other teaching and learning resources should be acquired to complement what is already in the schools so that more students will have easy access to these resources. To this end, heads of the senior high schools can appeal to old students of the schools and even educational non-governmental organizations for support to acquire these teaching and learning resources to add up to whatever the government has provided in the schools already which are inadequate.

- This study looked at the differential perceptions of SHS students and teachers of organic chemistry in the Asikuma Odoben Brakwa district of the central region of Ghana. In future research, a diagnostic test based on the topics in the SHS organic chemistry syllabus could be added to ascertain whether the perceived difficult topics are actually difficult for students to answer questions on. This would help teachers to separate perceived difficulties from the actual difficulties and be able to address them in their lessons.

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APPENDICES

Appendix A

Organic Chemistry Perceptions Questionnaire for Students (OCPQS)

This questionnaire is an instrument for a study that seeks to find out the perceptions of SHS chemistry students and chemistry teachers on organic chemistry. There is no right or wrong response.

SECTION A

BIO DATA

1. GENDER (TICK): MALE ☐ FEMALE ☐

2. AGE (Write in the box): ☐

SECTION B

GENERAL PERCEPTIONS ABOUT ORGANIC CHEMISTRY

Kindly indicate your level of agreement/ disagreement with the statements below by ticking under either strongly agree, agree, undecided, disagree or strongly disagree.

Statements	Strongly agree	Agree	Undecided	Disagree	Strongly disagree
1. Organic chemistry is a difficult topic for me. 2. Organic Chemistry concepts are very easy to understand 3. It is easy to solve organic chemistry problems. 4. I am very happy during organic chemistry lessons. 5. My chemistry teacher's method of teaching is more attractive and helped me to understand organic chemistry concepts well. 6. Organic chemistry is interesting. 7. I enjoy learning organic chemistry more than the other aspects of elective chemistry.					

SECTION C

PERCEPTIONS ABOUT ORGANIC CHEMISTRY TOPICS

Tick **(√)** the appropriate column corresponding to your opinion about the topic.

Please be sure to respond to all the items. If you change your mind about your response to an item just cross it out and tick **(√)** another. You are assured of the confidentiality of your opinion. Thank you.

TOPICS	**Very easy to understand**	**Easy to understand**	**Understood only after considerable effort**	**Difficult to understand**	**Very difficult to understand**	**Not taught**
1. Bonding in carbon						
2. Classification of organic compounds						
3. Identification of elements in organic compounds						
4. Separation and purification of organic compounds, empirical and molecular formulae						
5. Sources and characteristics of alkanes						
6. Naming of alkanes and structural isomerism						
7. Preparation, physical and chemical properties of alkanes						

TOPICS	Very easy to understand	Easy to understand	Understood only after considerable effort	Difficult to understand	Very difficult to understand	Not taught
8. Uses of alkanes						
9. Sources and characteristics of alkenes						
10. Naming of alkenes and isomerism in alkenes						
11. Preparation and chemical reactions of alkenes						
12. Uses of alkenes						
13. Sources and characteristic properties of alkynes						
14. Naming of alkynes and isomerism in alkynes						
15. Preparation and chemical reactions of alkynes						
16. Uses of alkynes						
17. The structure and stability of benzene						
18. Reactions of benzene						
19. Comparison of reactions of benzene and alkenes						

TOPICS	Very easy to understand	Easy to understand	Understood only after considerable effort	Difficult to understand	Very difficult to understand	Not taught
20. Preparation and properties of alkanols						
21. Physical properties of alkanols						
22. Naming of alkanols						
23. Primary, Secondary and tertiary alkanols						
24. Chemical reactions of alkanols						
25. Uses of alkanols						
26. Sources, preparation and properties of alkanoic acids						
27. Naming of alkanoic acids						
28. Uses of alkanoic acids						
29. Sources, preparation and properties of alkyl alkanoates						
30. Naming and structure of alkyl alkanoates						

TOPICS	Very easy to understand	Easy to understand	Understood only after considerable effort	Difficult to understand	Very difficult to understand	Not taught
31. Uses of alkyl alkanoates						
32. Soapy and soapless detergents						
33. Polymers and polymerization						
34. Petroleum						

35. Indicate the topic(s) you find most difficult to understand in organic chemistry.

List three of them, in order of difficulty.

1. ……

2. ……

3. ……

36. For the difficult topic(s) indicated above briefly explain why you find it difficult to understand.

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37. What do you suggest can be done to make organic chemistry more meaningful and interesting to you?

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Appendix B

Organic Chemistry Perception Questionnaire for Teachers (OCPQT)

This questionnaire is an instrument for a study that seeks to find out the perceptions of SHS chemistry students and chemistry teachers on organic chemistry. There is no right or wrong response.

SECTION A

BIODATA

1. GENDER (TICK): MALE ☐ FEMALE ☐

2. AGE (TICK): 23-34 yrs. ☐

35-44 yrs. ☐

45-60 yrs. ☐

3. ACADEMIC QUALIFICATION (TICK): DIPLOMA ☐ 1ST DEGREE ☐

2ND DEGREE ☐ OTHERS ☐

4. NUMBER OF YEARS IN TEACHING (Write in the box): ☐

SECTION B

GENERAL PERCEPTIONS ABOUT ORGANIC CHEMISTRY

Kindly indicate your level of agreement/ disagreement with the statements below by ticking under either **strongly agree, agree, undecided, disagree or strongly disagree**.

Statements	**Strongly agree**	**Agree**	**Undecided**	**Disagree**	**Strongly disagree**
1. Organic chemistry is a difficult topic for me to teach. 2. Organic Chemistry concepts are very easy to understand 3. It is easy to solve organic chemistry problems. 4. I enjoy teaching organic chemistry topics more than the other aspects of chemistry. 5. Organic chemistry topics are **not** interesting.					

SECTION C

PERCEPTIONS ABOUT ORGANIC CHEMISTRY TOPICS

Tick **(√)** the appropriate column corresponding to your opinion about the levels of difficulty of the topics listed below. Please be sure to respond to all the items. If you change your mind about your response to an item just cross it out and tick **(√)** another. You are assured of the confidentiality of your opinion. Thank you.

TOPICS	Very easy to teach	Easy to teach	Not sure	Difficult to teach	Very difficult to teach
1. Bonding in carbon					
2. Classification of organic compounds					
3. Identification of elements in organic compounds					
4. Separation and purification of organic compounds, empirical and molecular formulae					
5. Sources and characteristics of alkanes					
6. Naming of alkanes and structural isomerism					
7. Preparation, physical and chemical properties of alkanes					
8. Uses of alkanes					
9. Sources and characteristics of alkenes					
10. Naming of alkenes and isomerism in alkenes					
11. Preparation and chemical reactions of alkenes					
12. Uses of alkenes					
13. Sources and characteristic properties of alkynes					
14. Naming of alkynes and isomerism in alkynes					
15. Preparation and chemical reactions of alkynes					
16. Uses of alkynes					
17. The structure and stability of benzene					

TOPICS	Very easy to teach	Easy to teach	Not sure	Difficult to teach	Very difficult to teach
18. Reactions of benzene					
19. Comparison of reactions of benzene and alkenes					
20. Preparation and properties of alkanols					
21. Physical properties of alkanols					
22. Naming of alkanols					
23. Primary, Secondary and tertiary alkanols					
24. Chemical reactions of alkanols					
25. Uses of alkanols					
26. Sources, preparation and properties of alkanoic acids					
27. Naming of alkanoic acids					
28. Uses of alkanoic acids					
29. sources, preparation and properties of alkyl alkanoates					
30. Naming and structure of alkyl alkanoates					
31. Uses of alkyl alkanoates					
32. Soapy and soapless detergents					
33. Polymers and polymerization					
34. Petroleum					

35. In your opinion, what topics in organic chemistry do your students find most difficult to understand. List three (3) in order of difficulty; from most difficult to least difficult.

    1. ……
    2. ……
    3. ……

36. For the difficult topic(s) indicated above briefly explain why you think your students find it/them difficult to understand.

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37. What do you suggest can be done to make organic chemistry more meaningful and interesting to your students?

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