UNIVERSITY OF EDUCATION, WINNEBA

USING JIGSAW MODEL TO ENHANCE S.H.S CHEMISTRY STUDENTS' PERFORMANCE IN ORGANIC COMPOUNDS' CLASSIFICATION AND NOMENCLATURE

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DECLARATION

Student's Declaration

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

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Sarkodie Solomon Date

Supervisors' Declaration

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

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Dr. Emmanuel K. Oppong Date

(Supervisor)

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DEDICATION

This work is dedicated to my wife Benewah Mary, my children Sarkodie Jessiah and Ankomah-Dwomoh Sarkodie Rejoice, my brothers Adu- Gyamfi Joseph and Yeboah Benjamin and my friend Tabiri Eric.

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ABSTRACT

This study sought to improve Senior High School Chemistry students' performance and retention in classification and nomenclature of organic chemistry using the jigsaw cooperative model. Quasi experimental pretest, posttest and delayed posttest control group design was adopted by the researcher to carry out the study. The study was conducted in two Senior High Schools offering chemistry (two different classes during 2012-2013 academic years). Total number of ninety four students (94) obtained from the two intact classes of the two selected Senior High Schools in the Sunyani municipality of Brong Ahafo Region of Ghana participated in the study. One of the classes served as the control, taught with conventional traditional method while the other served as experimental or treatment, taught with the jigsaw cooperative technique. The instruments for obtaining data from students were the : Organic Chemistry Concept Test (OCCT), Students' Knowledge in Organic Chemistry Concept Test (SKOCCT), Students' Retention- Achievement Test in Organic Chemistry (SRATOC), and Chemistry Students' Perception and Attitude towards Organic Chemistry (CSPATOC). Statistical analyses revealed that there were significant differences between the experimental and control groups in terms of their attitudes and perceptions, academic achievement, and retention in favour of the experimental group. It was also found that the jigsaw cooperative learning model does not segregates female and male in terms of their academic performance in naming and classifying organic compounds.

In view of these, jigsaw cooperative methods should be used to enhance students' performance and retention in classification and naming organic compounds.

CHAPTER ONE

INTRODUCTION

Overview

This chapter deals with background to the study, statement of the problem, purpose of the study, objectives, research questions, significance of the study, delimitation, limitation, operational definition of terms and organization of report.

Background to the Study

The relevance of chemistry as a requirement for technological advancement of a nation cannot be overemphasized, although chemistry is seen by many science students as well as some science teachers as a difficult aspect of science. According to Anamuah – Mensah (1989), by having knowledge in science education the economy and social – cultural status of the nation will be transformed. This implies that science education (chemistry) is important in producing the required human resources needed for harnessing the natural resources of the country and yet the vast majority of students take chemistry as a required course for another discipline. Some factors which make chemistry difficult include its specialized language, mathematical nature, the amount of material needed to be learnt (Johnstone, 1984), and its abstract conceptual nature (Carter & Brickhouse, 1989; Zoller, 1990).

Research conducted in Science education by Anamuah-Mensah and Apafo (1986); found that the conceptualization of the chemistry aspect of science is indeed difficult for learners of science. The majority of our students essentially engages in rote learning and therefore appears to have difficulty in the understanding of some scientific concepts. Nakhleh (1992) and Boujaoude and Barakat (2000) emphasized that college students' knowledge of science is often characterized by lack of coherence and attributed this to the abstract and highly conceptual nature of science which seems to be particularly difficult for students.

The WAEC Chief Examiners' Report on chemistry' achievement of students at the May/June, 2007 and 2009 noted that generally, candidates' performances were poor as have been in previous years. Could these chronic poor performances be attributed to poor means of instructions? Could it be as a result of non availability of resources for teaching chemistry in the schools, or inefficiency in the use of the available material resources for instructions? Could it be attributed to students' poor understanding of concepts?

The teaching method employed by a teacher has been shown to reflect on students' understanding of the subject (Akinlaye, 1998). On this, Ajelabi (1998) was of the opinion that the teaching method adopted by the teacher in order to promote learning is of topmost importance. Hence, he concluded that there is the need to introduce, adopt, and adapt the latest instructional techniques that are capable of sustaining the interest of the learners.

In many public school setting, many classrooms have students with a wide range of abilities, but all are working toward the same goal though they learn and understand chemistry concepts in a variety of ways. Teachers have the difficult task of trying to identify which strategy works best for each individual student. It has become necessary to seek strategies that will employ approaches that ensure and enhance better academic performance of the students in the science subjects. In education today, it is now being recognized by many educationalists that there are better ways to learn than through the traditional methods of instructions (Wood & Gentile, 2003; & Akinbola & Ado, 2007).

One of the interesting modes of instruction is cooperative learning methods that enable students to have an active control over their own learning and also enhance students' academic achievement (Olatoye & Adekoya, 2009; Alebiosu, 1998; Okebukola, 1985). Instead of transmitting the knowledge in its final shape as in traditional method, knowledge gets formed in the process of student-teacher interaction, student-student interactions, and student-teaching content interactions in cooperative learning methods. One of the cooperative learning models is the jigsaw.

Statement of the Problem

Despite decades of research and curriculum development, modern students still do not adequately learn the necessary concepts to succeed in chemistry (Nakleh, 1992; Tyson & Treagust, 1999). This concern was also expressed by Dajili (2001) about the poor performance of students in science examinations. This concern arose from the increasing realization that the nation could not develop as rapidly as she aspired to without adequate tools of scientific and technological manpower at all levels in her working populace. He (Dajili, 2001) maintained that the state of science at the secondary school level was very important. This is because the performance at this level determines the quality and quantity of intake into the tertiary institutions in the country.

Students' performance in chemistry in general at the S.H.S level has been of great concern to most science educators. According to Ampiah (2001), SSSCE chemistry results over the years have been consistently below average. The chief examiners reports (WAEC, 2002) specifically stated that "the only organic chemistry question, referring to question 4 of the written section, was the most unpopular and was answered by very few candidates." (p. 98). The trend has not changed over the years since most students see questions on organic chemistry as difficult (WAEC, 2007, 2009). From the analysis of the researcher, every year (1993 – 2012) questions on organic compounds appear in the SSSCE or the WASSCE examination which means that the concept is very important at this level; it is therefore very important for students to have a good knowledge in it. Since one of the roles of every teacher especially the chemistry teacher, is to structure students' learning to ensure that specific concepts like organic chemistry are meaningfully learnt and internalized, it is imperative for chemistry teachers to adopt a strategy that will perhaps make instruction more efficient, effective and meaningful by actively involving students in the learning process, and hence reducing rote memorization. It is against this background that the intervention was employed to improve upon students' performance in classification and nomenclature of organic chemistry.

Purpose of the Study

The purpose of the study was to enhance S.H.S chemistry students' performance and retention in classification and nomenclature of organic compounds using jigsaw model of cooperative learning strategy.

Objectives of the Study

The study had the following objectives:

1. To assess the perceptions and attitudes of chemistry students towards organic chemistry concepts in the control and experimental groups.
2. To evaluate the academic performance of students in the control and experimental groups in classification and naming of organic compounds.
3. To find out the extent of students' retention of organic chemistry concepts in the jigsaw model groups and traditional chemistry group.
4. To determine any gender difference in performance with regard to the use of jigsaw in classification and nomenclature of organic compounds.

Research Questions

The following research questions guided the study.

1. What are the significant differences in the perceptions and attitudes of students towards organic chemistry concepts in the control and experimental groups?
2. To what extent is the academic performance of students in the experimental group significantly higher than students in the control chemistry class in classification and naming of organic compounds?
3. To what extent is the retention of organic chemistry concept in the jigsaw model group significantly higher than the retention of students in the traditional chemistry group?
4. What is the gender difference in performance of students in classifying and naming organic compounds using jigsaw method?

Hypotheses

The following null hypotheses were tested:

Ho_1: There is no statistically significant difference in the perceptions and attitude towards organic chemistry concepts held by students in the control group and students in the experimental groups.

Ho_2: There is no significant difference in academic performance of students in the experimental group and students in the control chemistry group in classification and nomenclature of organic compounds.

Ho_3: There is no statistically significant difference in the retention of classification and nomenclature of organic chemistry concept in the jigsaw model group and students in the traditional chemistry group.

Ho_4: There is no statistically significant gender difference in the performance of students in classifying and naming organic compounds using jigsaw model.

Significance of the Study

The research would generally stimulate students' interest and strengthen students' weakness in classification and nomenclature of organic compounds at Senior High Level. The findings of this study may be used in the following ways:

1. To add to existing knowledge of science education in Ghana on teaching and learning of organic chemistry.

2. To serve as reference material to ministry of education, Ghana education service in their development of curriculum and also to researchers who would like to do further research on the topic.
3. To enlighten teachers who are glued to the conventional methods of teaching organic chemistry through seminar organization, workshops and GAST annual conference.
4. To sustain the attention and interest of students in teaching and learning of organic chemistry.
5. To erase negative attitude and perception of chemistry students towards the learning of organic chemistry and other related chemistry concepts.

Delimitation

The study was delimited to two Senior High Schools offering pure chemistry in the Sunyani municipality of Brong Ahafo Region. The schools were selected based on accessibility and familiarity of the schools in the municipality to the researcher. This was also done in order to enable the researcher to undertake thorough and adequate data collection. The study was also focused on an aspect of organic chemistry; classification and nomenclature of organic compounds due to designed national syllabus for the Senior High School.

Limitation

According to Best and Kahn (1989), limitations are conditions beyond the control of the researcher that will place restriction on the validity of the study. Dusick (2011) also defined research limitations as those elements over which the researcher has no control.

The main limitation of the study was limited geographical representation of the two Senior High Schools only in the municipality places limitation on the extent of generalisation. Another limitation was a problem of reactivity. According to Ary, Lucy and Asghur (2002), reactivity is the unintended effect of outcomes of the study. The nature of reactivity experienced was the commitment level of the students to learn with jigsaw model. This made them feel uneasy at the very beginning of the of the data collection process since students are used to the conventional traditional method.

Operational Definition of Terms

Control group: A group of students whose performance is compared to that of experimental group.

Cooperative learning model: Cooperative learning may be broadly defined as any classroom learning situation in which students of all levels of performance work together in structured groups toward a shared or common goal

Experimental group: A group of students on whom the intervention is administered.

Expert group: A group of students from the home group who have the same learning task to learn.

Expert sheet: A set of instructions or an outline of topic in the form of questions which guides the students on the area to cover.

GAST: Ghana Association of Science Teachers

Gender differences: These are the differences as a result of being either a female or a male arising from social and cultural construction of roles associated with these differences.

Home group: A group of students who have a different part a whole task(jigsaw topic) to accomplish.

Jigsaw: Is a cooperative learning model in which students become experts on part of the instructional material about which they are learning. By becoming an expert, and then teaching other members of their team, making students becoming responsible for their own learning.

Performance: Scores in a test.

Retention: An ability of a student to retrieve a concept after some time interval.

S.H.S: Senior High School

S.S.S: Senior Secondary School

SSSCE: Senior Secondary School Certificate Examination

Organization of Report

The study report was organized under five chapters.

Chapter one dealt with, the background, the statement of the problem, purpose, research questions, hypothesis, significance, delimitation, limitation and organization of the study.

Chapter two was the review of the related literature for the study.

Chapter three covered the methodology.

Chapter four took care of results, findings and discussions.

Finally, chapter five was on the summary, the conclusions and the recommendation

CHAPTER TWO

LITERATURE REVIEW

Overview

This chapter contains the review of the literature related to the study and the theoretical frame work related to the important aspect of the study. The literature related to the study was reviewed under two main areas that is the theoretical and the empirical frameworks. The theoretical framework consisted of the behavourist and the constructivist theory of teaching and learning science in general. In the constructivist theory the following areas were looked at.

1. Theories of teaching and learning Science
   - i. Meaning of Behaviourism and Constructivism
   - ii. Constructivist Perspective of Learning
   - iii. Constructivist Perspective of Nature of the Learner
   - iv. Constructivist Teaching Strategies

The empirical review was done under the following areas:

2. Attitude and perception
   - i. Attitudes and perception of students towards organic chemistry concepts
   - ii Conception and misconception of students towards organic chemistry
   - iii. Studies about perceptions and attitudes towards organic chemistry
   - v. Influence of attitude and perception on student performance

3. Methods of teaching organic chemistry (jigsaw cooperative model and traditional style)
   i. Types of jigsaw models of teaching and learning
4. Factors that foster student' academic achievements in organic chemistry
   i. Student learning preferences
   ii. Teacher variable
   iii. Students' personality factors
5. Factors that influence students' retention of concepts in organic chemistry
6. Gender and performance in organic chemistry

The Theoretical Framework

Theories of teaching and learning Science:

Many theorists have made their contribution on how Science can be better learnt and taught. Some of the theories that the researcher came across are the behaviorist theories and the constructivist among others.

Behaviourism, as a learning theory, can be traced back to Aristotle, whose essay "Memory" focused on associations being made between events such as lightening and thunder. Behaviourism has been intrinsically linked with learning for many years. The concept of reinforcement (gaining something positive following an event to increase its likelihood of occurring again) is evident at all educational levels, from the smile of approval in early years to the awarding of credits and degrees at the higher levels (Jordan, Carlile, & Stack, 2008).

The theory of behaviorism concentrates on the study of overt behaviours that can be observed and measured (Good & Brophy, 1990). It views the mind as a "black box" in the sense that response to stimulus can be observed quantitatively, totally ignoring the possibility of thought processes occurring in the mind. Some key players in the development of the behaviourist theory were Pavlov, Watson, Thorndike and Skinner. Basically, to the behaviourist, learning is “any more or less permanent change in behaviour which is the result of experience” (Borger & Seaborne, 1966). Behaviourist theory of teaching and learning consider human beings to resemble machines, hence they believe that human behaviour is mechanical in nature. This means that human beings behaviour can be manipulated by reinforcement whether positive or negative. Other principles from behaviourist theory as it relates to teaching-learning process according to Brown (2004) include:

1. constant repetition of concepts by teachers will enable the learners to grasp and understand the concepts;
2. learning task should be concrete and progressively arranged;
3. positive and negative reinforcement should be used by teachers in the classroom;
4. there should be consistency in the use of reinforcers during the teaching-learning process;
5. habits and other undesirable responses can be broken by removing the positive reinforcers connected with them;
6. immediate, consistent, and positive reinforcement increases the speed of learning;
7. and once an item is learned, intermittent reinforcement will promote retention.

The summary of the behaviourist theory is based on stimulus-response learning. For many years, these behaviourist principles formed the basis of most of the learning theories applied in child rearing and in classrooms. It has been discovered that although stimulus response does explain many human behaviours, it has a legitimate place in instruction. However, modern educators have begun to conduct researches which tend to replace the behaviourist theories with new ones. One of such modern theory of learning is constructivism.

Meaning of Constructivism

According to Afolabi and Akinbobola, (2009), constructivism is a theory that suggests that learners construct knowledge out of their experiences which is associated with pedagogical approaches that promote learning by doing or active learning. Constructivist teaching focuses on independent learning, creativity, critical thinking and problem solving. Constructivist teaching is based on the fact that skills and knowledge acquisition are not by passive receiving of information and rote learning but involve active participation of the learners through knowledge construction, hands-on and minds-on activities (Akinbobola & Ado, 2007).

Bartlett pioneered what became the constructivist approach (Good & Brophy, 1990). Constructivists believe that learners construct their own reality or at least interpret it based upon their perceptions of experiences, so an individual's knowledge is a function of one's prior experiences, mental structures, and beliefs that are used to interpret objects and events. What someone knows is grounded in perception of the physical and social experiences which are comprehended by the mind (Jonasson, 1991).

According to Kliebard, (1992) John Dewey created an active intellectual learning environment in his laboratory school during the early 20th century. Neuroscience now supports this form of active learning as the way people naturally learn (Zull, 2002). Active learning conditionalizes knowledge through experiential learning. Smith'(1997) writes that John Dewey believed education must engage with and expand experience; those methods used to educate must provide for exploration, thinking, and reflection; and that interaction with the environment is necessary for learning; also, that democracy should be upheld in the educational process. Dewey advocates the learning process of experiential learning through real life experience to construct and conditionalizes knowledge, which is consistent with the Constructivists.

Constructivist Perspective of Learning

The constructivists argue that human beings generate knowledge and meaning from an interaction between their experiences and their ideas (Glasersfeld, 1989). The constructivist theory therefore recommends a teaching method that will encourage interactive activities among the learners. Some of the earliest protagonists of this theory are Piaget and Inhelder, (1969), who argued that play way method of teaching is an important and necessary point of the students cognitive development and he provided scientific evidence for his views.

Piaget (1945) articulated mechanisms by which knowledge is internalized by learners. He is of the view that through the process of accommodation and assimilation, individual’s constructs new knowledge from their experiences. According to him, incorporation of new experience into an already existing framework takes place when individuals assimilate new knowledge and this takes place without changing the existing framework. Assimilation may occur when individuals' experiences are aligned with their internal representations of the world and it may also occur as a failure to change a faulty understanding. For instance, an individual may not notice an event, he may misunderstand input from others, or he may decide that an event is a fluke and is therefore unimportant as information about the world. In contrast, when individual's experiences contradict their internal representations, they may change their perceptions of the experiences to fit their internal representations.

Accommodation, on the other hand, is the process of refraining one's mental representation of the external world to fit new experiences. It can also be understood to be the mechanism by which failure leads to learning. According to constructivist theory, as cited by Posner, Strike, Hewson, and Gertzog, (1982), when we act on the expectation that the world operates in one way and it violates our expectations, we often fail, but by accommodating this new experience and refraining our model of the way the world works, we learn from the experience of failure, or of others failure.

On the whole, constructivist's perception of learning suggests that learners construct knowledge out of their experiences. Constructivism is often associated with pedagogic approaches that promote active learning or learning by doing.

Constructivist Perception of Nature of the Learner

The constructivist perception of nature of the learner is as follows:

1. The constructivists see the learner as a unique individual with unique needs and backgrounds. (Merrill, 1991).

2. The learner is also seen as a complex individual hence he should be regarded as an integral part of the learning process.
3. Learners with different skills and backgrounds should collaborate in tasks and discussions to arrive at a shared understanding of the truth in a specific field (Duffy & Jonassen, 1991).

Social constructivism recognizes the importance of the background and culture of the learner; thus they encourage the learners' social interaction with knowledgeable members of the society. This will enable the learner to acquire social meaning of important symbol systems and learn how to utilize them. The constructivists encourage young children to develop their thinking abilities by interacting with other children, adults and the physical world.

It was also argued that the responsibility of learning should reside increasingly with the learner (Glasersfield, 1989). This means that learners should be actively involved in the learning process rather than being passive learners. According to Glasersfield (1989), sustaining motivation to learn is strongly dependent on the learner's confidence in his or her potential for learning. By experiencing the successful completion of challenging tasks, learners gain confidence and motivation to embark on more complex challenges. This view links up with Vygotsky's "zone of proximal development (ZPD) where learners are challenged within close proximity to get slightly above their current level of development (Vygotsky, 1978).

The social constructivist sees the role of the science teacher as a facilitator rather than a teacher. According to Gamoran Secoda, and Marrett, (1998), a teacher strive a didactic lecture that covers the subject matter while a facilitator helps the learner to get to his or her own understanding of the content. In teacher scenario, the learners are very passive in the learning process while in the facilitator scenario; the learners are actively involved in the learning process.

The constructivist sees learning as a social process where the learners interact among themselves thereby making learning meaningful. Again, the constructivist believes that there is dynamic interaction between the learning task, the instructor, and the learner. The role of the facilitator is to encourage the dynamic interaction. The above implies that the instructor and the learners are equally involved in learning from each other (Holt & Willard- Holt, 2000).

Constructivist Teaching Strategies

Constructivist teaching is based on constructivist learning theory. Constructivist teaching is based on the belief that learning occurs as learners are actively involved in a process of meaning and knowledge construction as opposed to passively receiving information. Learners are the makers of meaning and knowledge. Constructivist teaching fosters critical thinking, and creates motivated and independent learners. This theoretical framework holds that learning always builds upon knowledge that a student already knows; this prior knowledge is called a schema.

The constructivist's teaching strategies are as follows according to Honebein (1996);

Wilson & Cole (1991); Jonassen (1991):

1. that learning is best accomplished using a hands-on approach;
2. that learners learn by experimentation and not by being told what will happen;
3. that learners should be left to make their own discoveries, inferences and conclusions;
4. that teachers should commence their teaching by building upon the previous knowledge that the learner possesses;
5. that teachers role is not only to observe and assess but to also engage the students while they are completing activities;
6. that teachers are also to intervene when there are conflicts that arise in the course of their learning. They should facilitate the students' resolution and self-regulation, with an emphasis on the conflict.

On the basis of the above assertions by the constructivist, the following teaching strategies or approaches are recommended (Wilson and Cole (1991); Inquiry-based learning; problem-based learning; hands-on teaching approach; collaborative or group work; and cooperative learning among others.

Kim (2005) found that using constructivist teaching methods for 6th graders resulted in better student achievement than traditional teaching methods. This study also found that students preferred constructivist methods over traditional ones. However, Kim did not find any difference in student self-concept or learning strategies between those taught by constructivist or traditional methods.

Doğru and Kalender (2007) compared science classrooms using traditional teacher-centered approaches to those using student-centered, constructivist methods. In their initial test of student performance immediately following the lessons, they found no significant difference between traditional and constructivist methods. However, in the follow-up assessment 15 days later, students who learned through constructivist methods showed better retention of knowledge than those who learned through traditional methods. This study is guided by constructivism and social constructivism.

Empirical Framework

Perception and Attitude of Students towards Organic Chemistry

Historically, research on science education has focused primarily on cognitive educational outcomes. However, research into the affective domain has now become a major focus in science education, and one of the key variables within the affective domain that has drawn attention is attitude (Weinburgh, 1995). Ajzen (1989) proposed a theory of planned behaviour in which behavioural goals could be predicted from attitudes (Weinburgh, 1995). Since then, "many researchers have examined attitudes by studying variables that influence it" (Weinburgh, 1995, p.388).

Explanations and Definitions of Perception and Attitude

Students' performance in chemistry depends on many factors and stands out to show how well a student is doing. Allport (1968) described perception as the way people judge others with whom they are in contact. A person's attitude to an idea or object determines what the person thinks, feels and how the person would like to behave towards that idea or object.

Perception according to Microsoft Encarta (2009) is the process of using the senses to acquire information about the surrounding environment or situation. It also defined perception as the attitude or understanding based on what is observed or thought. According to Microsoft Encarta (2009), Perception is the process by which organisms interpret and organize sensation to produce a meaningful experience of the world. *Sensation* usually refers to the immediate, relatively unprocessed result of stimulation of sensory receptors in the eyes, ears, nose, tongue, or skin. Perception, on the other hand, better describes one's ultimate experience of the world and typically involves further processing of sensory input. In practice, sensation and perception are virtually impossible to separate, because they are part of one continuous process.

Our sense organs translate physical energy from the environment into electrical impulses processed by the brain. For example, light, in the form of electromagnetic radiation, causes receptor cells in our eyes to activate and send sign also to the brain. But we do not understand these signals as pure energy. The process of perception allows us to interpret them as objects, events, people, and situations.

Without the ability to organize and interpret sensations, life would seem like a meaningless jumble of colours, shapes, and sounds. A person without any perceptual ability would not be able to recognize faces, understand language, or avoid threats. Such a person would not survive for long. In fact, many species of animals have evolved exquisite sensory and perceptual systems that aid their survival.

Cambridge dictionary of philosophy also defines perception as the extraction and use of information about one's environment and one's own body (Audi, 1999, p.654).

Eggen and Kauchak (2001) gave cognitive dimension of perception; they see perception as the process by which people attach meaning to experiences. They explained that after people attend to certain stimuli in their sensory memories, processing continues with perception. Perception is critical because it influences the information that enters working memory.

Schunk (1996) defined attitude as internal beliefs that influence personal actions which is learned through one's experience. This has to do with a disposition to act or react in a particular way as the individual responds to a situation (Amoo & Rahman, 2004).

Attitude is an opinion or general opinion about something (Microsoft Encarta, 2009). The term attitude conveys different meanings in the science education literature. Knapper and Cropley (1985), explain attitudes as some psychological factors which influence students' willingness to engage in learning activities. Thus in their own words, students' willingness to learn are affected by attitudes, values and self images. To Marshal (1980), the will to work, is the essential ingredient for student to study. In 1929, Thurstone defined attitude as "the sum total of a man's inclinations and feelings, prejudice and bias, preconceived notions, ideas, fears, threats and convictions about a specific topic" (as cited in Abdalla, 1991, p. 96).

Various definitions of attitude can be restated in any of the following ways:

i. effect for or against
ii. evaluation of
iii. like or dislike
iv. positiveness or negativeness toward a psychological object

The characteristics of attitude as summarized by Goldstein cited as in Abdalla (1991) are as follows:

(i) Attitudes are learned

(ii) Attitudes predict behaviour

(iii) The social influences of others affect attitudes

(iv) Attitudes are evaluative, emotion is involved.

According to Katz and Stotland as cited in Akinmade (1992), attitudes have three components, namely; affective, cognitive, and behavioural. Adediwura and Tayo (2007) defined attitude as a consistent tendency to react in a particular way often positively or negatively toward any matter. Devine and Meagher (1989) categorized attitudes into two groups: namely positive and negative attitude. The difference between the two according to them is that while the positive attitude leads to better understanding and eventually to success, negative attitudes discolours ones understanding of life resulting to failure in life for that matter in school performance or achievement. This ascertation was affirmed by Eggen and Kauchak. According to Eggen and Kauchak (2001), positive teachers' attitudes are fundamental to effective teaching. The teacher must work his students into such a state of interest in what the teacher is going to teach them that every other object of attention is banished from their mind.

Students' performance in chemistry depends on many factors and stands out to show how well a student is doing. Festus (2007), contend that performance appears generally to be the fundamental goal behind every life struggle, but the positive platform has consequential effects of improving the worth of the student and can only be achieved through acquisition of positive learning attitudes. The attitudes of a student trigger his behaviour. Attitudes are antecedents which serve as inputs or stimuli that trigger actions. Attitudes can distort the reception and perception of information and affect the degree of their retention. Slee (1964) affirmed that students' attitudes and interest could play substantial role among pupils studying science. However, Rosemond (2006), opined that attitude implies a favourable or unfavourable evaluative reactions towards something, events, programmes, among others, exhibited in an individual's beliefs, feelings, emotions or intended behaviors. Wilson (1983) and Soyibo (1985), in their studies reported that students' positive attitudes to science correlate highly with their science achievement.

The meaning of attitude focused on in this review of the literature centered on affective reactions to organic chemistry. Attitude in this context implies interest, enthusiasm, satisfaction, enjoyment, feelings of like and dislike.

Conceptions and Misconception of Students towards Organic Chemistry

During the last three decades, with the effects of Constructivist learning theory, students' prior knowledge has gained importance in education. Many studies showed that students have some prior knowledge that is not scientifically correct (Driver &Easley, 1978; Driver &Erickson, 1983; Fleer, 1999). Students' conceptions that are different from those accepted by the scientific community are labelled as misconceptions (Nakhleh, 1992; Gonzalez, 1997).

According to Encarta dictionaries, (2009) misconception can be defined as a mistaken idea or view resulting from a misunderstanding of something. Hancock (1940), defined a "misconception" as "...any unfounded belief that does not embody the element of fear, good luck, faith, or supernatural intervention" (p. 208). Barrass (1984) wrote of "mistakes" or errors, "misconceptions" or misleading ideas, and "misunderstandings" or misinterpretations of facts, saying that teachers and brighter students can correct errors.

Many concepts in chemistry are important for learning and understanding how the world functions in daily life. However, students, either before or after school instruction, cannot develop an appropriate structure of chemistry concepts. For instance, students' conception of matter as a collection of moving particles is rudimentary, and the instruction in this area is not as effective as might be expected (Gabel & Bunce, 1994). Many studies have shown that students develop their scientific conceptions from many sources. Those sources have always created inconsistent frameworks or incorrect representation of the scientific concepts. The sources are personal experiences (e.g., observation), gender, peer interaction, media, language, symbolic representation, textbooks, and laboratory works. According to Chiu (2004) in a paper presented at the 18th ICCE, Istanbul, Turkey, 3-8 August 2004, regardless of grade level, students showed various causes for their conceptions of chemistry: these are daily life experience, textbooks, media, language, school instruction. Sometimes, teachers serve as another major source of alternative conceptions (Wandersee, Mintzes, & Novak, 1994). Research also revealed that students at different ages held similar misconceptions that influenced their understanding of more complex concepts.

Although much research has focused on investigating student misconceptions and developing teaching strategies for conceptual change, few researchers have focused on exploring the *causes* behind the misconceptions. For instance, Herron (1996) argued that languages in chemistry make learning difficult because the meanings of the same words in chemistry are different from the language used in daily life. Also, Oversby (2000) argued that models used in the textbooks only provide explanations of phenomena, and they have their strengths and limitations.

Studies about Perceptions and Attitudes toward Organic Chemistry

Gado, Verma and Simonis (2004) studied Middle Grade Teachers' Perceptions of their Chemistry Teaching Efficacy: Findings of a One year long Professional Development Program. They found out those teachers who experienced learning about chemistry concepts through the Conceptual Chemistry Professional Development program became more knowledgeable not only in chemistry concepts but became more confident about their abilities to put their experiences into practice in their classes. Also teachers provided with the opportunity to attend graduate level professional growth opportunities such as the Conceptual Chemistry Professional Development program may be one way to facilitate teachers' understandings of Chemistry concepts and teaching skills that could have a significant impact on teaching outcomes.

Available evidence from West African Examinations Council (WAEC) indicates that student's achievement in chemistry, especially at the Senior Secondary School level worsen as years go by and many students seen to have negative attitude towards the subject (Betiku 2002; Oyedeji 1992). The findings of Wood (1994) and Draphor (1994), which studied Senior Secondary School Students' perception of chemistry topics, indicated that chemistry students had difficulty with organic chemistry in general.

Influence of Attitude and Perception on Students Performance

Wrong perception and attitude about concept leads to misconception about that concept and eventually low performance will result. Many researchers, psychologists and educators alike, have identified some of the variables that have effects on students' academic performances. Academic performance is individual inherent potentials in terms of intelligence combined with other sociological factors.

Festus (2007), contend that performance appears generally to be the fundamental goal behind every life struggle, but the positive platform has consequential effects of improving the worth of the student and can only be achieved through acquisition of positive learning attitudes. The attitudes of a student trigger his behaviour. Attitudes are antecedents which serve as inputs or stimuli that trigger actions.

Many studies such as Anamuah-Mensah (1995) as well as Mahaja and Singh (2004) have however suggested that a direct relationship exists between students' performance in chemistry and their perception in chemistry. Attitudes can distort the perception of information and affect the degree of their retention. Slee (1964) affirmed that students' attitudes and interest could play substantial role among pupils studying science. However, Rosemond (2006), opined that attitude implies a favourable or unfavourable evaluative reactions towards something, events, programmes, etc exhibited in an individual's beliefs, feelings, emotions or intended behaviours. Wilson (1983) and Soyibo (1985), in their studies reported that students' positive attitudes to science correlate highly with their science achievement. Abimbade (1983) maintained that students exposed to programmed instruction recorded higher and more favorable attitude toward mathematics. Similar reports were recorded by Aiyelaagbe (1998), Udousoro (2000) and Popoola (2002), that students show more positive attitudes after been exposed to self learning strategy, such as computer and text assisted programmed instruction, self learning device and self instructed problem based.

Ojerinde (1981) in his study identified personality factors such as anxiety, achievement, motivation and level of interest as factors that affect academic performance. The consistence of these claims was asserted by Ford (1985), which claimed that students with high self-efficacy received higher grades than those with low self-efficacy and that students with negative self-concept have poor academic performance. Fazio and Roskes (1994), said, “attitudes are important to educational psychology because they strongly influence social thought, the way an individual thinks about and process social information”.

Research findings on teachers’ attitudes (Brunning, Schraw & Ronning, 1999), established the following facts: Teachers characteristics such as personal teaching efficacy, modeling and enthusiasm, caring and high expectation promote learners’ motivation. These same characteristics are also associated with increase in students’ achievement (academic performance). Akinmade (1992) suggested that the kinds of attitudes which students develop in their classrooms may be dependent upon how professionally and academically competent the science teacher is, as well as upon what the teacher does or does not do during his day to day transactions in the classroom.

The use of cooperative learning improves affective outcomes. Relative to students involved in individual or competitive learning environments, cooperatively taught students exhibited better social skills and higher self-esteems (Springer, Stanne, & Donovan, 1997) as well as more positive attitudes about their educational experience, the subject area, and the college (Johnson, Johnson, & Smith, 1998). Towns, Kreke and Field (2000), used field notes and survey data to analyze students' attitudes toward group activities in a physical chemistry class. The students viewed the group work as a positive force in their learning, and they also valued the interactions for promoting a sense of community in the classroom.

Methods of Teaching Organic Chemistry

The teaching method employed by a teacher has been shown to reflect on students' understanding of the subject (Akinlaye, 1998). On this, Ajelabi (1998) was of the opinion that the teaching method adopted by the teacher in order to promote learning is of topmost importance. Hence, he concluded that there is the need to introduce, adopt, and adapt the latest instructional techniques that are capable of sustaining the interest of the learners.

Science teaching-learning gains prominence on daily basis simply because of the consistent emphasis on Science and Technology due to its application in industrial development. This situation is not limited to the third world countries as even the developed countries are equally in the race. For instance, in 2000 the Australian government commissioned a research into Science in Schools (SiS) with the aim of developing an effective change strategy to support schools to improve science teaching and learning (Tyler, Waldrip, & Griffiths, 2004). Their interest was to develop a framework for describing effective teaching and learning of science. Over the last two decades there are reflections across nations that teaching and learning of science is problematic at the Secondary School level (Harlen, 1999; Tobin & Fraser, 1988; Yager, Hidayat & Penick, 1988). What this portends is that efforts made so far to improve the teaching and learning of science in secondary schools across the globe has not yielded the much needed results and therefore deserves further attention.

Okeke and Ezekannagba (2000) defined chemistry as a branch of science that deals with composition and changes of matter. Chemistry could therefore be defined as the science that deals with structure and composition of matter.

Chemistry at the Senior High School (S.H.S) level has three components. These are physical, inorganic and organic.

Organic chemistry touches every aspect of your life. This includes areas such as the clothes you wear, the food you eat, and the car you drive. Common to each of these items are chemical compounds based on the element carbon. Organic chemistry has both positive and negative attributes, and organic chemistry involves you. All living creatures, both plant and animal, consist largely of complex carbon-containing molecules. These molecules provide for the day-to-day operation and maintenance of each organism as well as for the continuance of the species. Interestingly, as chemists learned how to synthesize these complex molecules of life and the molecules that interact with them, organic chemistry came back to its roots. A part of the beginnings of organic chemistry was the study of compounds derived from the "organs" of living creatures—thus the name organic chemistry. Organic compounds permeate our everyday lives as we handle things such as polyesters, toothpastes and plastics. Now the knowledge gained from that research provides the basis for healing the diseases of many of those organs.

The term organic chemistry was originally referred to the study of chemical compounds present in living matters, but now it is defined in terms of the study of carbon compounds, except oxides of carbon, carbonates, and cyanides. The vast number of synthetic and natural organic compounds is due to the uniqueness of carbon; such as catenation (Danitith, 1981), exhibition of tetravalency and its ability to bond with other elements such as nitrogen, halogen, oxygen, and sulphur.

Organic chemistry as a component part of the S.H.S level chemistry is broad. Organic chemistry consists of many topics such as alkanes, alkenes, alkynes, and functional group compounds and it is only an integral part of the chemistry paper set by West Africa n Examinations Council (WAEC) at the West African Senior School Certificate Examination (WASSCE) level.

Organic chemistry has gained importance in general education in secondary schools and this has had effects on higher education courses. Elsewhere in United Kingdom, students at the University of Glasgow in their first year of study of chemistry, take organic chemistry, which covers the various functional groups and the general physical and chemical properties of organic compounds (Hassan, Hill & Reid, 2004). The organic chemistry is taught mechanistically, seeking to show students why the various groups of organic compounds behave in the way observed. Students are encouraged to ask questions such as, “what class of organic compound is this?” “What kind of reaction can I expect the organic compound to undergo?”

But in Ghanaian schools and colleges, it appears organic chemistry is usually taught by a didactic approach in which teachers deliver formal lectures to transmit knowledge thereby making students passive learners (Yingjie & Zaiqun, 2003). The traditional classroom can sometimes resemble a one-person show with a captive but largely uninvolved audience. Classes are usually dominated by lecture or direct instruction. The idea is that there is a fixed body of knowledge that the student must come to know. Students are expected to blindly accept the information they are given without questioning the instructor (Stofflett, 1998). The teacher seeks to transfer thoughts and meanings to the passive student leaving little room for student-initiated questions, independent thought or interaction between students (VAST, 1998). Even the laboratory activities, although done in a group, do not encourage discussion or exploration of the concepts involved. This tends to overlook the critical thinking and unifying concepts essential to true science literacy and appreciation (Yore, 2001).

The traditional method of teaching also assumes that all students have the same level of background knowledge in the subject matter and are able to absorb the material at the same pace (Lord, 1999). In the traditional learning setting the majority of interactions are teacher–student. This can create a competitive environment and produce a passive attitude toward learning as students vie for the teacher's approval (Killen, 2007; Harman & Nguyen, 2010). Despite the numerous disadvantages of the conventional methods, it has some advantages such as:

(i) More topics are covered in a relatively short period of time.
(ii) Students are given good training and insight into the techniques of analyzing issues.

(iii) The method is very suitable for teaching very large classes.

(iv) It is very easy in using to deliver knowledge.

The paradigm shift of education calls for the departure from the traditional teaching methods which are primarily teacher centered learning environment to new ones which are more learner centered. To help students understand chemistry, researchers have suggested a variety of instructional approaches, such as adapting teaching strategies based on the conceptual change model (Krajcik, Simmons & Lunetta, 1988), integrating laboratory activities into class instruction (Johnstone & Letton 1990), using concrete models (Copolo & Hounshell 1995), and using technologies as learning tools (Barne & Dori 1996; Kozma, Rusesell, Jones, Marx, & Davis, 1996). In chemistry education, however, learning methods are as important as teaching strategies. Used a lot, among the learning methods, is cooperative learning (Eilks, 2005; Hennessy & Evans, 2006; Wu, Krajac & Soloway, 2001).

Cooperative learning techniques have been shown to enhance students' learning and social relations relative to traditional whole class methods of teaching (Okebukola, 1984; Ojo, 1989; Alebiosu, 1998; Fuyunyu, 1998; Esan, 1999; Adeyemi 2002; Omosehin, 2004; Akinbode, 2006).

Cooperative learning comes in a variety of types. Different notable cooperative learning models used to improve student learning are reported in the literature: Student Teams-Achievement Division (STAD), Teams-Games- Tournament (TGT), Jigsaw, and Group Investigation (Abdullah, 2010). Others are Learning Together (LT), think-pair-share

(TPS), Team Assisted Individualization (TAI) among others. All these types of cooperative learning involve students working together in heterogeneous groups. In the STAD method, the teacher presents new material using formal teaching: lectures, discussion, or videos. In groups, the students then work together on a worksheet until they become a ‘master’. Each student takes an individual quiz, and their scores are combined to create team scores. The students that become winners are from the group with the highest score. The TGT method is different from the STAD method, in that the quiz and individual improvement scores are replaced with games and a ‘tournament’. The Think-Pair-Share: Students pair with a partner to share their responses to a question. Students are then invited to share their responses with the whole class. There are a variety of ways to share, including Stand Up and Share-everyone stands up and as each student responds he or she sits down. Anyone with a similar response also sits down. This continues until everyone is seated. Or do a “quick whip” through the class in which students respond quickly one right after another (Andrini, 1991).

Another model, Group Investigation, is more students directed in its approach. After the teacher presents an introduction to the unit, the students discuss what they have learned and outline possible topics for further examination. From this list of student-generated topics, each learning group chooses one and determines subtopics for each group member or team. Each student or group of students is responsible for researching his or her individual piece and preparing a brief report to bring back to the group. The group then designs a presentation (discourage a strict lecture format) and shares its findings with the entire class. Time is allowed for discussion and evaluation at the end of the presentation.

The Jigsaw method consists of two groups: a home group and an expert group. The lessons are divided into independent sub-topic. Each student becomes an expert in one sub-topic as part of a group investigation. In the Jigsaw model the student becomes a member of both a learning group and a research team. After determining the learning group's goal, the members join research teams to learn about a particular piece of the learning puzzle. Each puzzle piece must be solved to form a complete picture. The structure of knowledge is hierarchical, and each step can be studied separately and subsequently put together (Abdullah, 2010).

Types of Jigsaw Models

The original Jigsaw method was developed by Aronson, Blaney, Stepan, Sikes and Snapp in 1978, and its mode of operation is now explained in more detail. The method essentially consists of breaking down a large topic into a number of small topics, with the production of an 'expert sheet' prepared by the teacher. The students work in a 'home group' which is heterogeneous in nature. They (each home group member) are assigned to read an expert sheet, and then those who have the same expert sheet move from the home group to a separate expert group in which they then discuss their topic in detail. Once the discussion in the new group is complete, they return to their home group, and teach all their home group members about the topic that they are now expert in. Finally the groups are assessed, and individual grades are given.

The Jigsaw II method was modified from the original method by Slavin in 1986. This revised version of the method involves using computed team scores as for the STAD method. Aronson and Patnoe (1997) report that Jigsaw II has two substantial changes: all students in the team read all the lessons, and the scores of students are combined to contribute to an overall team score. This method has been used for subjects in the social sciences, and in science - particularly when the learning goals focus on concepts rather than skills (Slavin, 1990).

In the case of Jigsaw III, Gonzalez and Guerrero (1983) modified Jigsaw II to increase the interaction between students. Steinbrink, Walkiewicz and Stahl (1995) note that Jigsaw III has the addition of a cooperative test review process. This cooperative test review involves reconvening the home group and reviewing the process.

Finally, Jigsaw IV, developed by Holliday includes three important new features: an introduction, quizzes, and re-teaching after individual assessment (Holliday, 2002). In order to stimulate student interest in the lesson, the teacher first introduces the lesson by means of lectures, presentation of literature, questioning, proposing problems, or perhaps showing a movie in a ‘plenary’ class session. Students are then assigned to a heterogeneous group – the home group – and all students are assigned topics to read. Here each student discusses the expert sheet that is based on a list of all topics. Again, the students with the same expert sheet move to their expert group to discuss their topic. In order to check accuracy and understanding of students in the expert group, they are assessed by means of a quiz – this being based on the expert sheet. They return to their home group, teach all their group members and take quizzes all based on the original material. The teacher reviews and clarifies any concepts which it appears the students did not understand. The students take individual quizzes, and scores are combined to produce an overall team score. Finally, the teacher re-teaches any material which was misunderstood after the individual assessment process.

According to Holliday (2000), the three important features of Jigsaw IV are the introduction, the quiz, and re-teaching:

1. Introduction: The teacher introduces the lesson by means of lectures, literature, questions, problems or showing a movie. The purpose here is to stimulate student interest in the lesson;
2. Quiz: The students are evaluated by means of two quizzes:
    - The first quiz is designed to check the accuracy and understanding of student in the expert group – this is based on the expert sheet.
    - The second quiz is designed to check accuracy and understanding of students in the home group – this is based on all original material; and

Re-teach: The teacher re-teaches the material which they think has been misunderstood based on the individual assessment process. Holliday (2002) goes on to say that class activities can be sorted into nine processes.

1. Introduction. The teacher introduces the principle and experiment to the students in a plenary session, and assigns students to a home group, containing six students. The members of each home group are divided into expert groups;
2. Expert sheets assigned to expert groups;
3. Answer expert questions prior to returning to home group. The students are asked questions based on their expert sheet to check their understanding prior to returning to their home group;

4. Quiz on material in the expert groups checking for accuracy. The teacher administers quizzes to assess the validity of their responses;
5. Return to home groups to share their information with their group. The students return to their home group to teach their peers, and to share information with each other in their home group;
6. Quiz on material shared, checking for accuracy. The students are asked questions based on all original material;
7. Review process. The teacher reviews and clarifies any concepts which appears the students did not understand;
8. Individual assessment and grade. Each student is re-assessed using a post-test; and
9. Re-teach. The teacher re-teaches any topics found to be difficult based on the post-test assessment. (P. 182,183)

In all the types of Jigsaw methods, students are assigned to study specific topics in an expert group, they become the expert on their topic, and subsequently they teach their home group members. This means they have the opportunity to teach and learn in their groups, they are able to share their ideas; they develop their self-confidence, cooperation and motivation (Barbosa, Jofili, & Watts, 2004). In other words, the students are able to improve in both cognitive and affective ways (Eilks, 2005). As noted earlier, the Jigsaw methods are used in science classes more than other collaborative learning methods, because the structure of much science knowledge is hierarchical, meaning each step can be studied separately and then put together – like a jigsaw! (Lazarowitz & Hertz-Lazarowitz, 1998). Research suggests that students improve in terms of attitude towards science, at the same time they achieve cognitively (Eilks, 2005). In particular, it seems students improve their critical-thinking skills (Aronson & Patnoe, 1997; Ulrich & Glendon, 1995), and are able to approach the critical thinking process involving: analysis, reflection, synthesis, and reconstruction (Charania, Kausar, & Cassum, 2001; Ulrich & Glendon, 1995). Overall then, although the Jigsaw method is a rather complicated teaching approach, students are able to develop critical thinking skills (Charania et al., 2001), and learn how to lead discussions (Colosi & Zales, 1998).

The Jigsaw method has been reported to improve affective variables for a variety of science students. For example, in introductory chemistry laboratory courses, Smith, Hinckley and Volk (1991) used the Jigsaw method to address a lack of student preparation, and poor understanding of chemistry concepts for acid/base chemistry. Here, the students had to conduct a part of the experiment, and share their data, and the results from their groups. It seems the Jigsaw method had a positive effect on the laboratory class, and in particular for low-achieving students who showed the greatest gains in post-tests of conceptual understanding. In addition, the literature suggests that the Jigsaw methods also work well for abstract topics like atomic structure. Eilks (2005), for example, reports on the use of Jigsaw II to teach atomic structure in grade 9 and 10 chemistry classes. In this study, students were required to read the text, do an experiment, and explain some models for atomic structure. It seems students were more attentive in the classes, and enjoyed science lessons – pointing to affective gains. They said they enjoyed working in small groups, and felt they had more freedom to make individual or group decisions. Charania et al. (2001) likewise investigated student perceptions of learning in a Jigsaw method-based class, and reported that when students discussed their specific topic within their expert group, they increased in conceptual understanding, developed self- confidence, and enhanced communication skills. Of particular interest to chemistry teachers is the fact that the Jigsaw method is reported to work well for the teaching of problematic topics that involve shifting from macroscopic to microscopic levels of representation (Johnson, 1990). Fleming (1995) investigated the effectiveness of cooperative learning in a micro-scale laboratory, and reported that when students discussed organic chemistry topics within their groups, they could better solve difficult problems, and understood and enjoyed their classes more.

In science education, the Jigsaw method and its variants are reported to be used in classes more often than other collaborative learning methods, especially in biology, chemistry, and physics and the Earth sciences. This is because the Jigsaw method is considered to enhance cooperative learning by making each student focus on a particular topic. Because of this, Aronson and Patnoe (1997) conclude that the Jigsaw method is the most useful collaborative learning method because students must discuss and communicate the meaning of their topics, meaning they develop critical thinking and problem-solving skills. In support of this, Slavin (1990) observes that the Jigsaw method is particularly useful because students must take an active role in learning something. Colosi and Zales (1998) believe is true because students learn a subject best when they have to explain it to their peers.

Jigsaw is said to be able to increase students' learning since "a) it is less threatening for many students, b) it increases the amount of student participation in the classroom, c) it reduces the need for competitiveness and d) it reduces the teacher's dominance in the classroom" (*Longman Dictionary*, 1998). Consequently, jigsaw strategy can successfully reduce students' reluctance to participate in the classroom activities and help create an active learner-centered atmosphere. Studies have shown that it is only under certain conditions that cooperative efforts maybe expected to be more productive than competitive and individualistic efforts. Johnson,

Johnson and Holubec (1993) put forward five principles for effective jigsaw strategy:

a. Positive interdependence

Each group member's efforts are required and indispensable for the group success. Each group member has to make unique contributions to the joint effort.

b. Face-to-face promotive interaction

Group members have to orally explain how to solve problems, teach one's knowledge to others, check for understanding, discuss concepts being learned and associate the present learning with the past one.

c. Individual and group accountability

The size of the group should be kept small, for the smaller the size of the group is, the greater the individual accountability may be.

d. Interpersonal skills

Social skills are a necessity for the success of jigsaw learning in class. Social skills include leadership, decision-making, trust-building, communication, conflict-management skills and so on.

e. Group processing

Group members discuss how well they are achieving their goals and maintaining effective working relationships, describe what member actions are helpful and what are not, and make decisions about what behaviours to continue or change.

Jigsaw learning makes it possible for students to be introduced to material and yet bear a high level of personal responsibility. It helps develop teamwork and cooperative learning skills within students and a depth of knowledge not possible if the students learn all of the material by themselves. Finally, since students are supposed to report their own findings to the home group in jigsaw learning, it quite often discloses a student's own understanding of a concept as well as reveals any misunderstanding.

Problems Associated with Cooperative Methods of Teaching and Learning

In terms of students' preferences for teaching methods, a study by Qualters (2001) suggests that students do not easily accept active learning methods because of the in-class time taken by the activities, fear of not covering all the materials in the course, and anxiety about changing from traditional classroom expectations to the active structure. A group of cognitive scientists have also questioned the central claims of constructivism, saying that they are either misleading or contradict known findings (Kirschner, Sweller, & Clark, 2006). One possible deterrent for this teaching method is that, due to the emphasis on group work, the ideas of the more active students may dominate the group's conclusions.

Factors that Foster Academic Performance in Science- Chemistry

Academic performance could be defined as the display of knowledge attained or skills developed in school subjects designated by test and examination scores or marks assigned by the subjects' teachers. It could also be said to be any expression used to represent students' scholastic standing. The key to your success in organic chemistry is in what you learn. Studying organic chemistry is like combining the elements of a foreign language class with the elements of logic, or mathematics.

A number of studies have been carried out to identify and analyse the numerous factors that affect academic performance in various centres of learning. Their findings identify students' effort, previous schooling (Siegfried & Fels, 1979; Anderson & Benjamin, 1994), parents' education, family income (Devadoss & Foltz, 1996), self motivation, age of student, learning preferences (Aripin, Mahmood, Rohaizad, Yeop, & Anuar, 2008), class attendance (Romer, 1993), and entry qualifications as factors that have a significant effect on the students' academic performance in various settings.

Students' Learning Preferences

A good match between students' learning preferences and instructor's teaching style has been demonstrated to have positive effect on student's performance (Harb & El-Shaarawi, 2006). According to Reid (1995), learning preference refers to a person's "natural, habitual and preferred way" of assimilating new information.

This implies that individuals differ in regard to what mode of instruction or study is most effective for them. Scholars, who promote the learning preferences approach to learning, agree that effective instruction can only be undertaken if the learner's learning preferences are diagnosed and the instruction is tailored accordingly (Pashler, McDaniel, Rohrer, & Bjork, 2008). "I hear and I forget. I see and I remember. I do and I understand." (Confucius 551-479 BC) a quote that provides evidence that, even in early times, there was a recognition of the existence of different learning preferences among people. Indeed, Omrod (2008) reports that some students seem to learn better when information is presented through words (verbal learners), whereas others seem to learn better when it is presented in the form of pictures (visual learners). Clearly in a class where only one instructional method is employed, there is a strong possibility that a number of students will find the learning environment less optimal and this could affect their academic performance. Felder (1993) established that alignment between students' learning preferences and an instructor's teaching style leads to better recall and understanding.

Teachers variable are also noted to have effect on students' academic performances. These include, teachers' knowledge of subject matter, teaching skills, attitude in the classroom, teachers' qualification and teaching experience. Francisco, Nicoll and Trautmann (1998), Gabel (1999), Ezeliora (2004) and Okoli (2006) reported that poor teaching methods adopted by science teachers during instruction is one of the causes of students' colossal failure in science examinations and remarked that these teaching methods and techniques do not seem to make learning sufficiently easy for students. Alexander (1992) also suggests that, teachers have focused more on content rather than pedagogy and this affects outcome. He argues that content and pedagogy are linked. McDiamind and Anderson (1989), Anderson and Miller (1994), Alexander (1992), point out that the teacher's knowledge or skills and methods of delivering a subject either enhances or limits students' learning.

Research by Marzano (2003) and Darling-Hammond (2001) indicates that a teacher's pedagogical knowledge is associated with higher student achievement. Teachers must be able to interpret learners' statements and actions and shape productive experiences for them. A study by Okunlola (1985) showed that a significant positive relationship exists between quantity and quality of teachers and the academic performance of their students.

Ehindero and Ajibade (2000) asserted that, "students, who are curious stakeholders in educational enterprise, have long suspected and speculated that some of their teachers (lecturers in the university) lack the necessary professional (not academic) qualification (that is, skills, techniques, strategies, temperament among others) required to communicate concepts, ideas and principles in a way that would facilitate effective learning". They also believed that these deficiencies contribute significantly to the growing rate of failure and subsequent drop out of students in tertiary institutions.
Just as there is a significant growing rate of failure and subsequent drop-out in the Ghana higher institutions, so it is happening in the Ghanaian's Senior High Schools. The growing failure rate could essentially be noticed in the yearly decline in students' performance in the West African Senior School Certificate Examination (WASSCE). This thus, is making many students to abandon schooling at the end of Senior High School years.

Halliman, Bottoms, Pallas, and Palla, (2003), state that the three determinants of learning are quantity and quality of instruction, student motivation, and academic climate and they are interrelated. The strength of an academic climate is dependent on the quantity and quality of instruction, and both of these factors influence student motivation. When these factors co-vary in a way that fosters learning, students are provided with rich educational opportunities and experiences, and they are most likely to attain high achievement. When one or more of these determinants of learning is weak, student performance is expected to suffer. When students have strong motivation to succeed and work with peers in a friendly environment, they improve their performance level and engagement in learning Organic Chemistry.

Talking about quality and quantity of instruction, Scholars have linked this high rate of low performance to several factors, including a reliance on large lecture-based courses and lack of engaging pedagogy. Although it may represent an efficient method for presenting a tremendous amount of content to a large audience, lecture tends to encourage one-way, passive, superficial learning (Bransford, Brown & Cocking., 2000; Moore, 1996; Seymour & Hewitt, 1997). Additionally, lectures tend to promote memorization over conceptual understanding (Bligh, 2000; Booth, 2001; Knight & Wood, 2005).

Ojerinde (1981) identified personality factors such as anxiety, achievement, motivation and level of interest as factors that affect academic performance. The consistence of these claims was asserted by Ford (1985), which claimed that student with high self-efficacy received higher grades than those with low self-efficacy and that student with negative self-concept have poor academic performance.

Hmelo-Silver, Duncan, and Chinn (2007), on the effectiveness of inquiry-based science for middle school students, as demonstrated by their performance in high-stakes standardized tests, the improvement was 14% for the first cohort of students and 13% for the second cohort. This study also found that inquiry-based teaching methods greatly reduced the achievement gap for African-American students.

Fennema and Frank (1992) agreed that teacher's knowledge of the subject matter is an indicator of teachers' teaching effectiveness. Regarding the demands placed on teachers as facilitators, Ayers (1993) writes:

> Teaching is instructing, advising, counseling, organizing, assessing, guiding, goading, showing, managing, modeling, coaching, disciplining, prodding, preaching, persuading proselytizing, listening, interacting, nursing, and inspiring. Teachers must be experts, generalists, psychologists and cops, rabbis and priests, judges, and gurus. (pp. 4-5)

Factors that Influence Retention of Scientific Concepts

Retention according to American Heritage dictionary is the condition of retaining (keeping) something. You may be able to memorize fact in the short-term, but how well is your retention of those facts over the long-term? Thus retention is the ability to keep facts and figures for a period of time. Without retention there can't be a successful transfer of knowledge from one subject area to another

Bahrick (1979) suggests that students do not retain the information acquired in a class for long after an examination. Higbee (1977) echoes that same sentiment. More recent studies, however, show that although some information is forgotten (Conway, Cohen, & Stanhope, 1991; Semb, Ellis, & Aranjo, 1993), the retention loss is not as great as expected (Cooper & Greiner, 1971; Semb, Ellis, & Montague, 1990). Bahrick, (1984), and Bahrick and Hall (1991) found that retention can last up to fifty years.

The studies of retention have explored, at least somewhat, whether retention differs for different types of knowledge. Semb, Ellis, and Aranjo (1993) define four types of knowledge-recall, recognition, comprehension, and cognition. In their study, retention of recall knowledge was significantly lower than the other three. Semb and Ellis (1994) argue that there are two dimensions of the retention interval that can affect retention-length, and what occurred during the interval. With regards to the length of the interval, there are consistent findings that the amount retained declines in a non-linear manner (Bahrick, 1984; Bahrick & Hall, 1991; Glasnapp, Poggio & Ory, 1978).

Farr (1987) suggests that the degree of original learning is the most important variable to long-term retention. Bahrick and Hall (1991), in a study of Spanish and mathematics students, found a strong correlation between the level of original learning and long-term retention.

Mathews (1989) confirmed that a pupil's level of attainment was directly, related to the length of time actively spent in learning. This finding was also supported by the International Assessment of Educational Progress (IAEP) Projects in 1991/92. According to Kraft (1994, pp.17) not only do Ghanaian children spend less time in school than many others, but that the actual academic learning time is less by two to three hours a day. This means that the underutilization or mismanagement of instructional time will result in a limited coverage of the designed curricula, which will finally have negative effect on students' performance. It is perhaps for this reason that Hurd (2002) suggests increasing the amount of time allocated for active experimentation in life science as a way of increasing participation by students who are poorly motivated. He noted that often teachers use teacher-centered instructional techniques and assign seat work to unmotivated students while more motivated students perform laboratory activities and are given assessment involving problem-solving. As indicated by Sheppard and Robbins

(2002, p .429) there has been very little discussion about the time allocation for science in U.S high schools.

Gender and Performance in Organic Chemistry

According to Wall (1997), gender is the natural differences between men and women, which dictate on their occupational choice, while Liebert (1992) and Okou (1991) concluded that sex has a strong influence on vocational occupation.

Ssempala,(2005) and Hodson,(1999), observed that there is disparity in male-female performance in sciences . Studies carried out by Tamir (1982) and Burns (2001) in Israel and New Zealand respectively, have also shown that male students outperformed their female counterparts in the physical sciences. The report of similar study conducted by Anderson (2002) indicated that in America, there were too few women in the sciences and related professions like Engineering and Technology.

Zhu (2007) reported that girls tended to use more concrete strategies and boys tended to use more abstract strategies and that elementary school boys tended to be more flexible in employing strategies on extension problems than elementary school girls. He also reported that girls chose to use more standard algorithms than boys at the end of Grade 3. This report by Zhu (2007) is in contrast to a study by Ehindero, Adeleke, Oloyede, and Ajibade (2009) who stated that girls have higher achievement scores than boys in logical reasoning, linguistic, reading and word-problem solving abilities. They stated that the issue of gender influence on students' performance in mathematics and science is not straight jacketed. They further argued that boys perform better than girls only in conventional classroom arrangements and in the overall science tasks but not in some tasks that are also very crucial to the learning of Mathematics and Science.

In addition the study by Ehindero et al (2009) support some aspect of the report by Zhu (2007) that among high school high-ability students there is no overall gender difference in the numbers of correctly answered items, but under different situations, females and males approached mathematical problems by using different strategies. Ehindero et al (2009) concluded that the difference between male and female science students is at best relative depending on the context of the investigation and the content being examined. While males may outperform females in conventional science context dominated by mathematics and experimentation, females achieve higher than males in certain skills that are very necessary to the learning of science. This was confirmed by a study about the difficult level of organic chemistry topics in the Central Region of Ghana by Davis (2010). He observed that female students therefore found organic chemistry topics less difficult to understand than male students.

Okeke (2002), reported that boys perform better than girls on physical science questions and high level questions (applications, analysis and synthesis) whereas girls do as well as, or better than boys on questions in Biological sciences and lower level (knowledge, recall and comprehension) questions. Research study carried out by Okeke (2002),) focused mostly on the effect of gender factors on students' understanding of science process skills in science learning among junior secondary schools students in some eleven (11) selected junior secondary schools (classes 1 – 3) from Zaria and Sabon Gari Local Government Areas of Kaduna State. The target was 330 students that were chosen through the stratified sampling method. The results show that: (1) the subjects possessed low understanding of science process skills. (2) The female students were significantly better in their understanding of science process skills than their male counterparts. (3) There was significant difference between the male and female students in their ability to solve problems requiring their understanding of the process skills as pre-requisites for achievement in Biology.

A study by Boli, Allen and Payne (1985) explored the reasons behind the differences that were observed between the genders in undergraduate chemistry and mathematics courses. Their exploration sought reasons behind why male students were tending to outperform the female cohort, resulting in the suggestion that differences in mathematical ability were a very important consideration.

The most important factor, through an analysis of previous studies, was that the male students' natural self-confidence and belief in the importance and need for mathematics had a positive influence on male performance.

These findings with regard to mathematics can be fairly and evenly transferred to the natural sciences (Boli, et.al;1985) and chemistry. Other than mathematics, there appeared to be no directly gender-related reasons for the male students outperforming the female students yet the evidence showed that this was the case. The study also showed that females were less likely to choose mathematics and science courses at the undergraduate level, often because of lesser preparation at the prior levels of schooling, Blickenstaff, (2005); Spelke, (2005) and Buccheri, Gurber, and Bruhwiler, (2011).

Many studies have agreed with the observation that male students usually outperform female students in assessments particularly in the areas of mathematics and science. The analysis of a number of large assessments has demonstrated that male students generally performed better than did female students, Beller, & Gafni, (2002); Kuyper, van der Werf, & Bosker, (2011); Neuschmidt, Barth, and Hastedt, (2008).

According to research, self-efficacy influences the choice and engagement in a task, the effort expended in performing it, and the standard of the performance (Bandura & Schunk, 1981; Bandura, 1986; Hackett & Betz, 1989). Since its introduction, the concept of self-efficacy has gained increasing importance as a significant variable for the prediction of individual behaviour. Bandura (1997) states that gender and attitude influence academic performance to some extent through their mediating effects on self-efficacy beliefs.

Summary of Reviewed Literature

Organic chemistry touches almost every aspect of life. This may include areas such as the food we eat, the clothes we wear, the car we drive and others. Therefore effective comprehension and coherent understanding of its principles and concepts are required in order to get the best from its study. BouJaoude and Barakat (2000) affirmed that students' knowledge of science is often characterized by lack of coherence and attributed this to science's abstracts nature. In view of this, the literature highlighted the theories of teaching and learning that would enhance the performance in science in general and organic chemistry in particular. The researcher identified two types of theories- Bahaviourism and Constructivism.

Bahaviourism is basically concerned with learning which result in more or less permanent change in overt behaviour. It was observed that this theory uses the convectional traditional method which is teacher- centered approach. It has been in operation for many years in our science classrooms. The concept of reinforcement (of something positive following an event to increase its likelihood of occurring again) is evident at all educational levels, from the smile of approval in early years to the awarding of credits and degrees at the higher levels (Jordan, Carlile, & Stack, 2008). Though this traditional teacher centered method has some weakness as observed in the literature, it has a legitimate place in instruction.

Constructism is another theory of learning which was looked in the literature. This theory argues that human beings generate knowledge and meaning from interaction between their experiences and ideas (Glasersfeld, 1989). This theory was seen as theory associated with pedagogic approaches that promote active learning. It was also realized that constructivist teaching methods resulted in better student achievement than the traditional teaching methods.

The literature also highlighted the types of teaching methods used in teaching organic chemistry. Didactic approach in which traditional conventional methods of teaching organic chemistry and student centered were identified. It was observed that there is paradigm shift from traditional methods to student centered methods such as cooperatives methods. Different methods of cooperative models were highlighted such as jigsaw, team investigation, team assisted individualization, learning together, among others.

Perception and attitude of students towards organic chemistry were discussed. Attitude and perception were defined. Perception as a process of using senses to acquire information about the surrounding environment or situation and attitude according to Schunk (1996) as internal belief that influence personal actions which is learned through one's experience.

It was observed that the behavioural goal could be predicted from attitude and perception. An attitude implies interest, enthusiasm, feeling of like and dislike satisfaction, and enjoyment . According to Eggan and Kauchak (2001), positive teachers' attitudes are fundamental to effective teaching and learning.

The literature also looked at the conception and misconception towards organic chemistry. It was observed that students either before or after school instruction, cannot develop an appropriate structures of chemistry concepts. Sources of students' conceptions towards organic chemistry were identified as personal experiences, gender, peer interaction, language, textbooks, media, and sometimes teachers serve as another source of alternative conception.

Factors that foster academic performance in chemistry were another area that the literature highlighted. It was observed that students' effort, previous schooling, parents' education, self motivation, age of student, learning preference, class attendance, teacher' variable, quality and quantity of instruction, and academic climate among others have a significant effect on the students' academic performance in various settings. It was also seen that the personality factors such as anxiety, achievement, motivation and level of interest have effect on academic performance of students.

Retention of scientific concept factors was also looked into. It was seen that there is strong correlation between the level of original learning and long term retention of learning material. It was observed that students do not retain the information acquired in class for long after an examination. Finally the literature highlighted gender and performance in organic chemistry. Studies carried out by Tamir (1982) and Burns (1987) in Israel and New Zealand respectively, have also shown that male students outperformed their female counterparts in the physical sciences. It was seen that there is disparity in male-female performance in sciences such chemistry.

In this study, the questionnaires, and test items were used to collect data from the control and experimental groups of students. The details of the methodology are presented in the next chapter (Chapter Three).

CHAPTER THREE

METHODOLOGY

Overview

The methodology looks at the research design, the population, sample, the sampling techniques, and the data collection instrument. The chapter also includes validity and reliability of the instrument, intervention, data collection procedure and the mode of analyzing the data.

Research Design

Writing on research design, Leedy, (1993) stated that, the nature of the data to be collected and the problem for the research dictate the research methodology. In searching for appropriate design, the researcher considered various designs such as case study, developmental design, survey, action research, experimental, quasi- experimental design and others.

The research design that was appropriate to the researcher was quasi- experimental. This is an empirical study used to estimate the causal impact of an intervention. This kind of design includes at least an experimental (treatment) group and a control group and it is best type of design often available for field studies when causal inference is desired. This was selected because it minimizes the treats to external validity; the idea of having any manipulation the researcher so chooses. Two forms of quasi-experimental studies identified are a pre-post test design study without a control group and a pre-post test design with a control group.

1. Pretest-Post test design study without a control group

A pretest-post test design requires that data is collected on study participants' level of performance before the intervention took place (pre-), and that the same data is collected after the intervention has taken place (post-). This study design only looks at one group of individuals who receive the intervention, which is called the treatment group. The pre-post test design allows inferences to be made on the effect of the intervention by looking at the difference in the pre-test and post-test results. However, interpreting the pre-test and post-test difference is done with caution since the researcher could not be sure that the differences in the pre-test and the post-test are causally related to the intervention.

2. Pretest, post test design with a control group. The pretest, post test with control group gives the true potential effects of the program or intervention, since the treatment group receives the intervention. However, the control group gets the business-as-usual conditions, meaning they only receive interventions that they would have gotten if they had not participated in the study. By having both groups that received the intervention and another group that did not, the researcher is able to compare the potential impact of the intervention which the first method cannot achieve.

In this research the second approach was used; the pretest, posttest with control group approach. The participants were in two groups; one group (experimental) was exposed to classification and nomenclature of organic chemistry using jigsaw cooperative model and the second group (control group) was also exposed to the same concept using the conventional teaching method (lecture). All participants were pre-tested in an organic chemistry concept test. Post and Retention- achievement test/delayed post test were also conducted to all the groups after the intervention.

Study Design

Target population

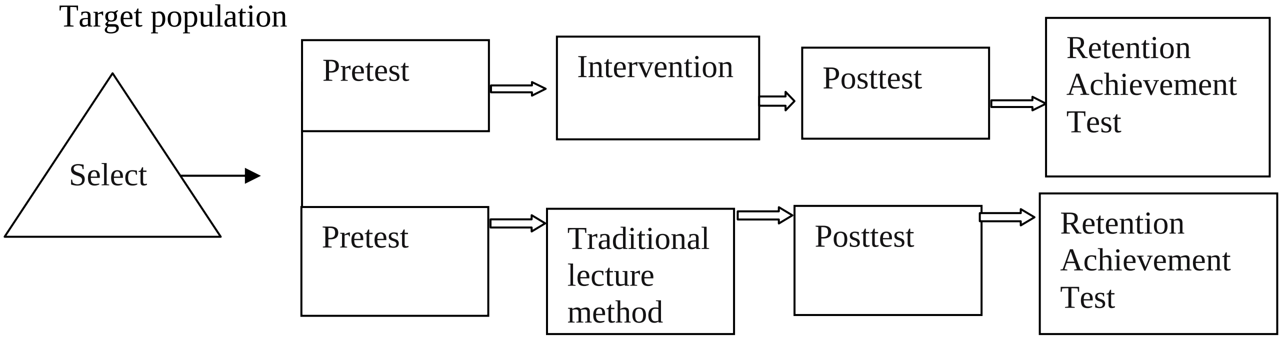

Figure 1: The research design selected for the study

Population

The target population was all senior high students offering chemistry in Sunyani municipality in the Brong Region. The accessible population however was two intact chemistry classes in two schools in the target population. One of the classes was used as the control group and the other the experimental group by random sampling method. The use of the intact classes was to avoid distortions of the academic activities in the participating schools. As Campbell and Stanley (1963) explained, it would become predictably certain that the groups' posttest scores would differ independent of any experimental treatment effect. Therefore, classes of comparable standards were used, and their comparability was established by means of pre-test scores which assessed students' knowledge in basic organic chemistry concepts. Two second-year intact (science) chemistry classes from the selected schools were used for the study.

Sample and Sampling Procedure

The very fact that we cannot use the entire population makes the operation involving sampling statistically vital. Sampling is the process of selecting a portion of the population to represent the entire population. Purposive sampling technique was employed to select the sample (both the school and the classes) for the study. This was because of the distance of the schools to the researcher, the willingness of the school head and teachers to cooperate and topic of the researcher.

The samples were drawn from two schools in Sunyani municipality in the Brong Ahafo Region of Ghana. The selection of the schools depended on the distance of the schools to one another in order to remove knowledge dissemination and contamination effect, and the willingness of the school heads and teachers to cooperate in the study. One of the schools was used for control group and other for experimental group. These schools were distant from each other though in the same municipality to minimize their interaction. In both groups S.H.S two (2) students offering chemistry were selected. This was because the chemistry of carbon is to be taught in the second year according to the Ghanaian Chemistry Teaching Syllabus for Senior High Schools (S.H.S 1-3).

The schools were selected based on accessibility to the researcher and also the schools selected were all science government assisted schools. The sample of this study consisted of the total of 94 S.H.S two chemistry students. One of the classes was defined as Jigsaw Technique Group (JTG) (n=60) and was taught by jigsaw techniques while the Conventional Method Group (CMG) n=34 and where taught using the traditional method. The assignment was done by purposive sampling.

Instrumentation

This study employed data triangulation or the use of multiple data collection process which involves comparing and integrating quantitative and qualitative methods (Patton, 2002). Bogdan and Biklen (2003) advocate for triangulation of data because, "…multiple

sources lead to a fuller understanding of the phenomena you were studying."
Triangulation of data attempts to gain a deep understanding of the topic at hand (Denzin & Lincoln, 2000). In this study, jigsaw instrument, the test items, and questionnaire were used.

Jigsaw Instrument

Two lesson plans on classification and nomenclature in organic chemistry were prepared by the researcher and presented to a panel of experts for their comments and suggestions. Ultimately corrections on the plans were effected before being used for the intervention. The topic focused on nomenclature and classification in organic chemistry as stated in the teaching syllabus for S.H.S. There are four jigsaw teaching and learning techniques which are: Jigsaw I commonly called Jigsaw, Jigsaw II, Jigsaw III and Jigsaw IV.

Instruction with the Jigsaw IV Teaching Technique

The researcher considered Jigsaw IV because it had addition or important features such as introduction of the concept, quizzes and re-teaching of challenging concepts after individual assessment which other jigsaw types lack.

The intervention in the study is called the Jigsaw IV teaching technique which was used for the treatment of the experimental group in 40- minutes' lessons (five times a week) which lasted for four weeks.

The jigsaw group students were randomly divided into two groups (30 students +30 students). Figure 2 represents one of these parts (30 students). The other part was organized in the same way as the first. These students were divided into five home groups in classification and nomenclature of organic compounds. For example, in the following subtopics (a) alkenes (b) alkynes (c) alkanols (d) alkanoic acids and (e) alkyl Alkanoates. In this instance, each home group contained five students; each student was assigned a specific subtopic to learn as homework or assignment. In this experimental group, there were twelve (12) home groups (i.e. six home groups for part A and six home groups for part B). Students with the same subtopic form the expert groups.

After the formation of the home and the expert groups, the researcher introduced how the jigsaw intervention was going to work effectively in the learning to the students. After the explanation on the intervention, researcher briefly introduced the concept of classification and nomenclature of organic chemistry to the jigsaw class and the following steps were followed to complete the process.

1. The students moved into the expert groups and expert sheets were assigned to them. The expert sheets were on the following areas; alkane and alkenes, alkynes and benzenes; alkanols, alkanoic acids and alkyl Alkanoates.
2. Expert groups discussed the expert sheet and answered the oral questions asked by the researcher. This was done to check their understanding before returning to the home groups. There were ten expert groups in the experimental class; each group with six students; each student from each home group. In the expert group, the students prepared summary reports and then each jigsaw group prepared a teaching strategy for its members which were used to explain the sub topic to their home groups' members.
3. The researcher administered quizzes to assess the validity of their responses.

4. The students return to their various home groups to teach their peers and share information with each other.
5. The teacher reviews and clarifies any concepts which appear they did not understand or have some misconception.
6. The teacher re-assessed the individual students using the post test and the delay post test. The purpose of the delayed post test was to find out the retention ability of the two groups involved in the study.
7. The teacher re-teaches any subtopics found to be difficult based on the post test and delayed post test.

The diagrams below showed the formation of home groups, expert groups, and the expert groups moving back to their home groups to teach their peers.

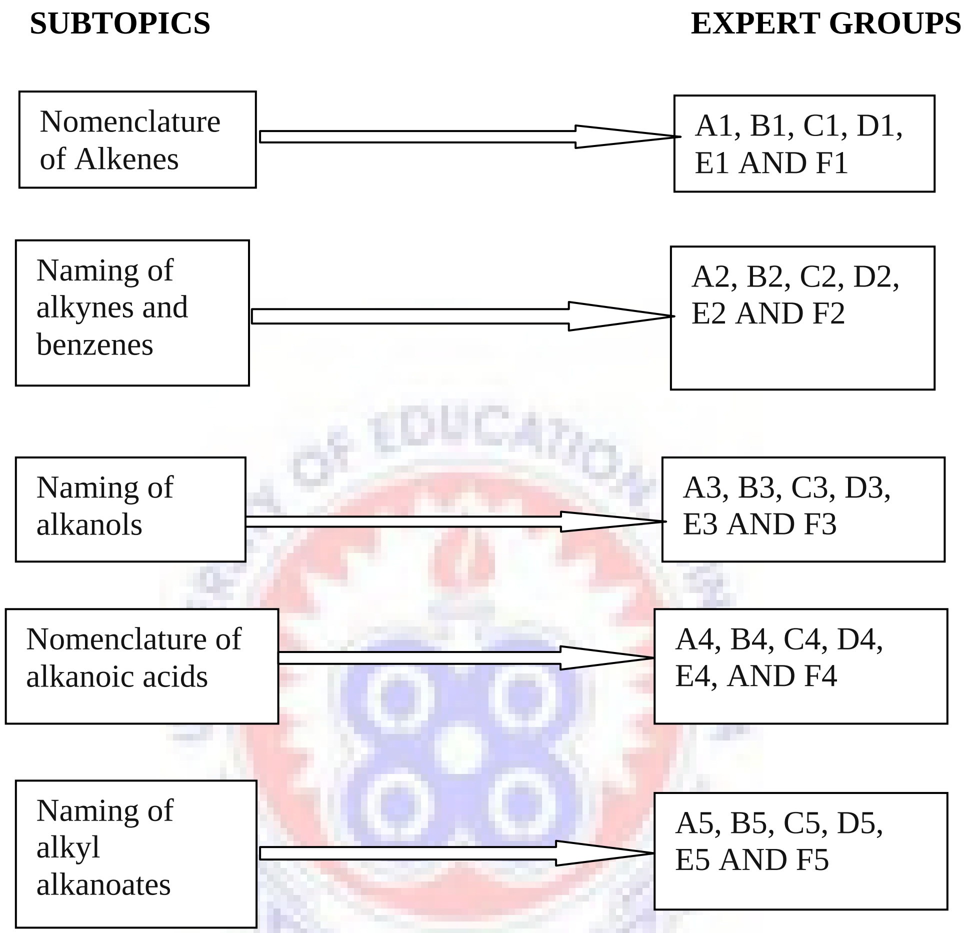

Fig 2: Sub- topics of classification and nomenclature of organic compounds and expert groups representing (A1, B1, CI, etc. Stands for Individual Students from a Group)

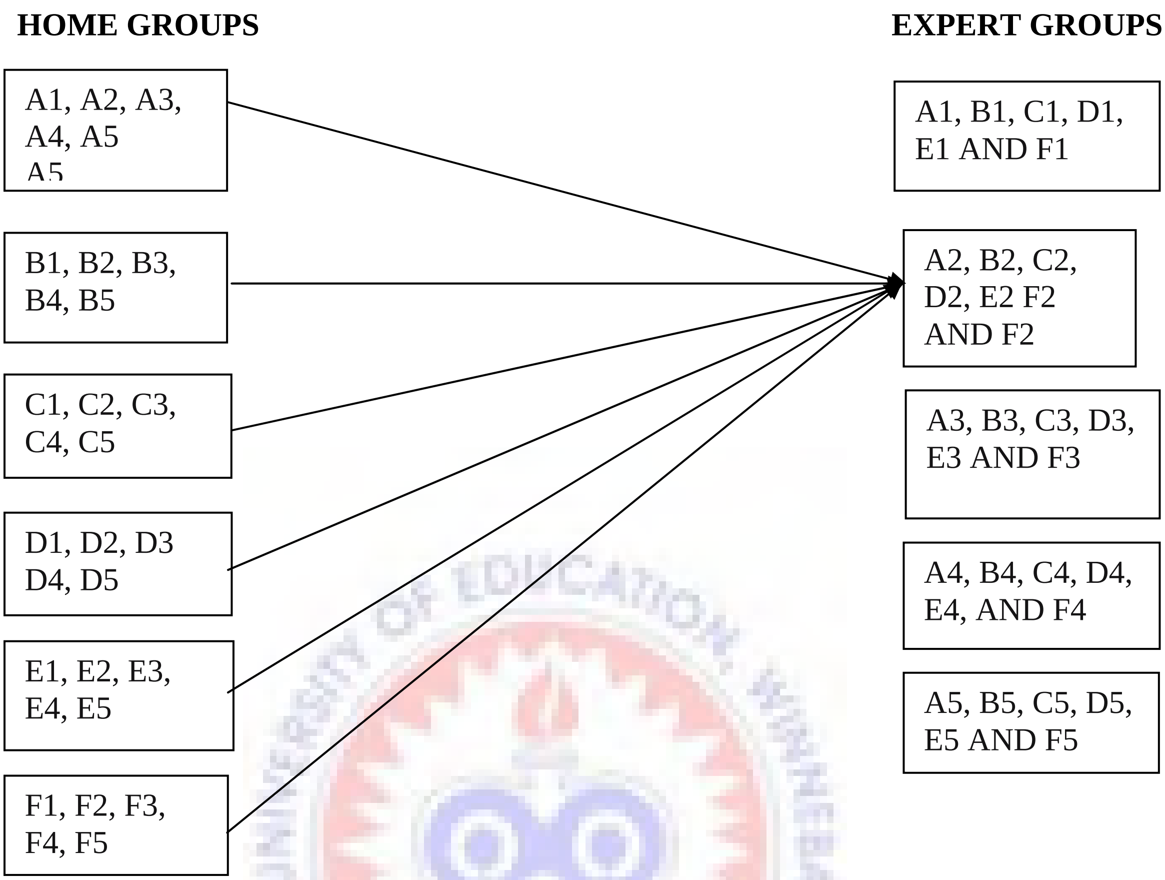

Fig.3: Forming of Expert groups from Home group

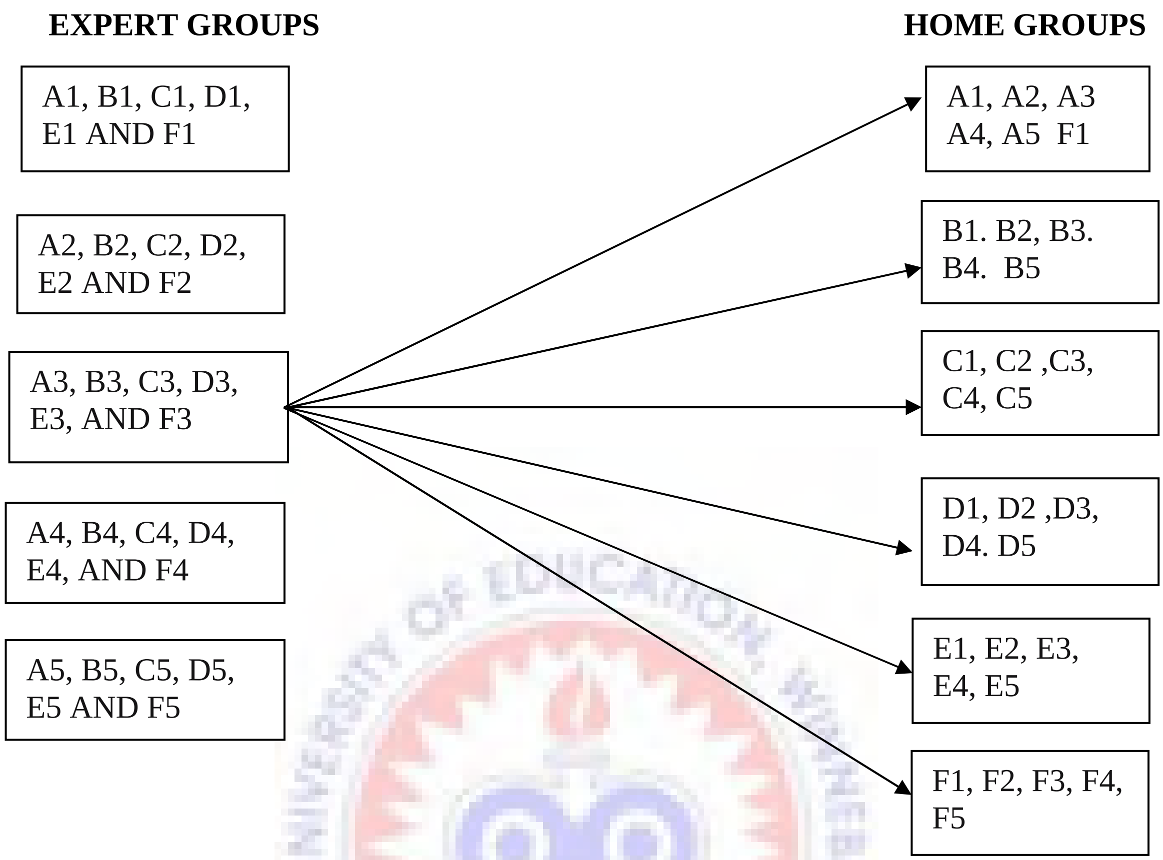

Fig.4: Expert groups moving to their Home groups to teach their peers

Instruction with Conventional Method (CM)

Lesson plan on the concept of nomenclature in organic chemistry was also developed using the conventional lecture method. For this method group, classroom activities were not based on the jigsaw teaching technique but those activities typically found in all traditional classrooms teaching method which was teacher-centered. The treatment of the control group students also lasted for four weeks.

Test Items

The test items covered what the students were taught in organic chemistry. The items were developed along three process categories of objective: remembering, understanding and thinking. The test items were:

Pre-test: Organic Chemistry Concept Test (OCCT). It was made up of forty (40) items in two sections; A, and B. the 40 items were marked over forty marks; each item carried one mark.

Post- test: Students' Knowledge in Organic Chemistry Concept Test (SKOCCT). The post test items were in three sections; A, B and C. Section. A was multiple –choice objective test, section B was fill – in the blank test and section C was true or false test. The post test was also forty items.

Students' Retention Achievement Test in Organic Chemistry (SRATOC). This test was the same as the post test but it was administered 15 days after the post test.

Questionnaire

Questionnaire was chosen because it is effective in securing information from the respondents within shortest possible time (Macmillan, 1996). The questionnaire could be completed at the respondent's own convenience. Moreover, it offers assurance of anonymity.

A set of self developed questionnaire was used; the questionnaire on the perception and attitude of chemistry students towards organic chemistry for both groups were administered before the intervention.

Chemistry students' perception and attitude towards organic chemistry questionnaire consisted of twenty (20) items. The items focused on students' perception and attitude towards organic chemistry in general using the Likert scale format. The options include Strongly Agree (SA), Agree (A), Disagree (DA), and Strongly Disagree (SD). The respondents were to tick the appropriate option that applied in their case

Validity of the Instrument

Validity refers to whether the instrument accurately measures what was intended (Patton, 2007). To ensure the face and content validity of the instruments, the instruments were validated by giving it to two experienced secondary school chemistry teachers and two senior lecturers in the Science Education Department of the University of Education-Winneba for critique and suggestions which were used to modify the final version of the instruments.

Pilot Testing

The questionnaires were pre-tested at Sunyani Senior High School in the Brong-Ahafo Region of Ghana. The school was selected because it shares similar characteristics with Senior High Schools selected for the study. The pilot study enabled the researcher to restructure the research instruments to help elicit the right responses.

Reliability

Joppe (2000) defines reliability as extent to which results are consistent over time. According to Creswell (2009), reliability refers to whether scores to items on an instrument are internally consistent, stable over time, and whether there was consistency in test administration and scoring. A reliability test was conducted by determining the Crombach's alpha. Cronbach alpha was then used to calculate the coefficient of reliability. Cronbach alpha Coefficient of the instruments OCCT and SKOCCT (STRATOC) were found to be 0.72 and 0.78 respectively. Also the coefficient for Chemistry Students' Perception and Attitude towards Organic Chemistry (CSPATOC) was found to be 0.79. These were then compared with the tabulated coefficient of reliability which according to Aryl ,Jacobs and Razzavieh (2002), for test item instrument which measures intellectual achievement to be accepted, it should have Cronbach alpha Coefficient reliability of not less than 0.72. Also according to Amoah and Onivehu (2002), the reliability level of 0.3 to 1.0 was considered reliable. The schools and students for establishing the reliability of the instruments did not take part in the major study.

Data Collection Procedure

The researcher sought permission and approval from the headmasters and the head of science departments of the various schools to undertake the study.

Chemistry Students' Perception and Attitude towards Organic Chemistry (CSPATOC) questionnaire was administered to all the groups after permission was granted to the researcher. The attitude and perception questionnaire (CSPATOC) was administered first in order to avoid the influence of the chemistry achievement test on students' attitude.

Pre-test was then conducted in the control and the experimental groups. The organic chemistry concept (classification and nomenclature of organic compounds) were then introduced using both jigsaw cooperative model and the traditional conventional methods for the experimental and control groups respectively within four weeks and post- test was then administered in the fifth week. After two weeks, the retention- achievement test or the delayed post test was given to all the groups. The essence of delayed posttest was to find out whether students were able to retain the organic chemistry concepts taught.

Data Analysis

According to Osuala (1993), data analysis is the ordering and breaking down of data into constituent parts and the performing of statistical calculations with the raw data to provide answers to the questions initiating the research.

The collected data were analyzed by applying descriptive and inferential statistical measure. Coding schemes were developed to organize the data into meaningful and manageable categories. The categorized data were later converted into frequency counts and simple percentages and were used to answer the research questions generated in the study; this descriptive statistical approach was used in the analysis of the qualitative part of the data. Descriptive statistics which involved the computation of pre-test, post test and the delayed post test mean scores; standard deviation and variance for each variable were done.

Data collected were processed using the Statistical Package for Social Science (SPSS). The pre-test and post-test scores of students were analyzed statistically using independent sample t-test. The post test and retention achievement test scores of both schools were also analyzed using the same sample t-test. A *t*-test was used to compare the achievements of male and female students in both control and experimental groups.

Inferences were drawn from the statistical analysis results to answer the research questions and to test the hypotheses. The details of the data analysis are presented in the next chapter (chapter four).

CHAPTER FOUR

RESULTS AND DISCUSSION

Overview

This chapter presents the statistical analysis of the research data. Inferential statistical evidences needed for drawing conclusions have been provided. Again, tested hypotheses, interpreted results, as well as evidence-based answers to the research questions have also been presented.

To find out the differences in perceptions and attitudes of chemistry students (control and experimental) towards organic chemistry concept, the research question one was posed as:

Research Question One

What are the significant differences in the perceptions and attitudes of students towards organic chemistry concepts in the control and experimental groups?

In order to address this research question, students were asked to indicate their responses to the items on a questionnaire CSPATOC.

A four point Likert scale was used in scoring students' responses on the Likert scale items, "strongly agree" was scored 1 point, which is the maximum on the scale; "Agree", was also scored 2 points; "disagree" points 3; then followed by "strongly disagree" 4 points, which is the minimum on the scale. The overall mean less than 3.0 mean positive perception and attitude and above 3.0 represent negative attitude and perception.

The total score for the S.H.S chemistry students' responses to the perception and attitude towards organic chemistry concept was computed using SPSS. The total mean score was found to be 45.46 and the overall mean score was 2.273 which is the total mean score divided by the number of statements or items. This shows that the S.H.S chemistry students' perception and attitude towards organic chemistry concepts was generally positive since the overall mean was less than 3.0.

Table 1a and b give the differences that exist between the control and experimental groups about their perceptions and attitudes towards organic chemistry.

Table 1(a): Responses of Students' Perception and Attitude of the Experimental Group towards Organic Chemistry Concept (N=60)

Serial No.	Item	Response					
		SA (%)	A (%)	DA (%)	SD (%)	Mean	Standard Deviation
1	Chemistry is difficult especially organic chemistry.	5.0	25.0	33.3	36.7	3.02	0.911
2	Organic chemistry is very interesting	36.7	45.0	11.7	6.6	1.88	0.865
3	Organic compound structures are more terrifying	18.3	45.0	28.3	8.3	2.27	0.861
4	Naming of hydrocarbons is confusing	20.0	41.7	26.7	11.7	2.30	0.926
5	The food aspects in organic chemistry make it practical	38.3	35.0	16.7	10.0	1.98	0.983
6	The organic chemistry textbook is not helpful.	18.3	15.0	40.0	26.7	2.75	1.052
7	Organic chemistry is not usable in daily life situations, and is not important to learn.	10.0	6.7	38.3	45.0	3.18	0.948
8	I participate in chemistry discussions often, and it is enjoyable.	50.0	41.7	5.0	3.3	1.62	0.739
9	Chemistry knowledge is necessary in my future career.	63.3	30.0	1.7	5.0	1.48	0.770
10	I have enjoyed studying organic chemistry	41.7	41.7	6.6	10.0	1.85	0.936
11	Organic chemistry lessons are very boring.	18.3	20.0	36.7	25.0	2.68	1.049
12	I am always under a terrible stress in chemistry class.	10.0	21.7	33.3	25.0	2.83	0.924
13	Organic chemistry concepts and its structures are unfamiliar to me	21.7	30.0	25.0	23.3	2.50	1.081
14	Organic chemistry makes me restless, irritable, and impatient	13.3	28.3	38.3	20.0	2.65	0.954
15	I have good feelings toward chemistry in general	58.3	31.7	6.7	3.3	1.55	0.769
16	I am comfortable with chemistry and it is not difficult very much	48.3	41.7	10.0	0.0	1.62	0.666
17	Organic chemistry knowledge is necessary in my future career.	48.3	30.0	13.3	8.3	1.82	0.965
18	It makes me nervous to think about problem solving in organic chemistry.	11.7	10.0	31.7	46.6	2.52	1.016
19	I don't like organic chemistry and I am afraid to learn it.	18.3	31.7	30.0	20.0	3.31	1.017
20	I like chemistry because of the teacher	33.0	28.3	21.7	17.0	2.22	1.091

Note: SA=strongly Agree; A=Agree; DA=Disagree; SD= Strongly Disagree

Table 1(b): Responses of Students' Perception and Attitude of the Control Group towards Organic Chemistry Concept (N=30)

Serial No	Item	Reponses (%)				Mean	Standard Deviation
		SA	A	DA	SD		
1	Chemistry is difficult especially organic chemistry.	23.	36.7	23.3	16.7	2.33	1.028
2	Organic chemistry is very interesting	43.3	43.3	10.0	3.4	1.73	0.785
3	Organic compound structures are more terrifying	26.7	40.0	30.0	3.3	2.10	0.845
4	Naming of hydrocarbons is confusing	38.7	43.3	10.0	10.0	1.93	0.944
5	The food aspects in organic chemistry make it practical	36.7	23.3	23.3	16.7	2.20	1.126
6	The organic chemistry textbook is not helpful.	20.0	10.0	13.3	56.7	3.07	1.230
7	Organic chemistry is not usable in daily life situations, and is not important to learn.	13.3	13.4	23.3	50.0	3.10	1.094
8	I participate in chemistry discussions often, and it is enjoyable.	53.3	30.3	10.0	6.4	1.70	0.915
9	Chemistry knowledge is necessary in my future career.	80.0	16.7	3.3	0.0	1.27	0.640
10	I have enjoyed studying organic chemistry	50.0	13.3	36.7	00	1.70	0.837
11	Organic chemistry lessons are very boring.	10.0	13.3	30.0	46.7	3.13	1.008
12	I am always under a terrible stress in chemistry class.	13.3	26.7	30.0	30.0	2.77	1.040
13	Organic chemistry concepts and its structures are unfamiliar to me	23.3	36.7	23.3	16.7	2.33	1.028
14	Organic chemistry makes me restless, irritable, and impatient	20.0	16.7	16.7	46.6	2.90	1.213
15	I have good feelings toward chemistry in general	53.3	30.0	16.7	0.0	1.80	1.095
16	I am comfortable with chemistry and it is not difficult very much	43.3	26.7	20.0	10.0	1.97	1.033
17	Organic chemistry knowledge is necessary in my future career.	65.5	20.7	10.3	3.5	152	0.829
18	It makes me nervous to think about problem solving in organic chemistry.	30.0	33.3	13.3	23.4	2.30	1.149
19	I don't like organic chemistry and I am afraid to learn it.	10.0	20.0	16.7	53.3	3.13	1.077
20	I like chemistry because of the teacher	53.3	20.0	13.3	13.4	1.89	1.106

Note: SA=strongly Agree; A=Agree; DA=Disagree; SD= Strongly Disagree

From the tables 1a and b above, it was deduced generally that the perception and attitude of the control and experimental groups were similar, since out of 20 items 15 of the mean scores were within the same range. Thus, strongly agree was scored 1, which was maximum point on the scale, agree = 2, disagree = 3, and 4 for strongly disagree which was minimum on the scale.

The experimental group (N=60) had a total mean score and overall mean score of 46.0 and 2.30 respectively while the control (N=30) had total mean score and overall mean score of 44.87 and 2.24 respectively.

The means of the control and the experimental groups of the attitude and perception towards organic chemistry have been presented in the bar chart as shown in the figure 5.This Figure compares the means of the experimental groups and the control groups.

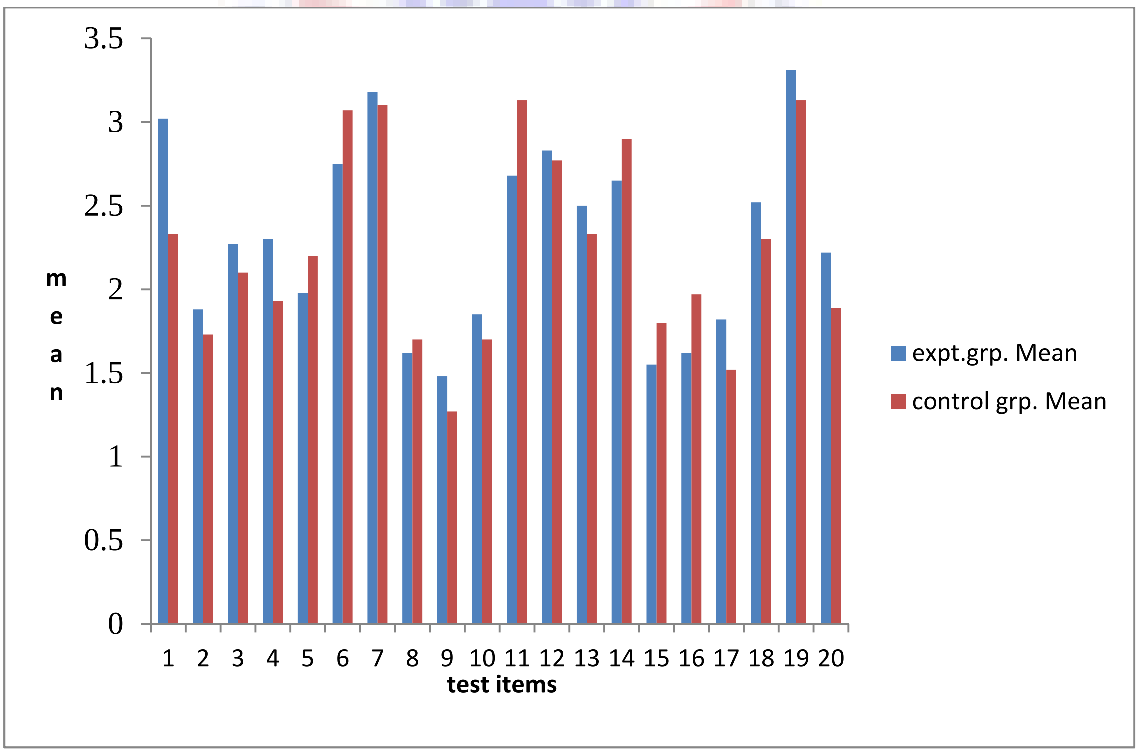

Fig. 5: Perception and attitudes by the two groups

Though in figure 4, it was deduced that there were difference in the perceptions and attitudes to CSPATOC questionnaire for the two groups, there was a need to find out whether the difference was significant. Therefore the Research Question One was formulated into a null hypothesis as:

Ho_1: There is no statistically significant difference in the perceptions and attitude towards organic chemistry concepts held by students in the control group and students in the experimental groups.

The 2-tailed t-test for independent samples was used to determine whether significant differences existed between the experimental and the control groups in their perception and attitude towards organic chemistry concept. The independent sample t-test analyses of the CSPATOC mean score of both groups showed no significance difference ($t(38) = 2.024$; $p > 0.05$) between the two groups. This showed that there was no significant difference in the perception and attitude towards organic concept between the control and experimental groups before the study. This indicated that the null hypothesis (Ho_1) was accepted. The outcome of the analysis is displayed in Table 2 and figure 6.

Table 2: The t-test for Independent Samples Analysis of the CSPATOC Mean Scores of the Control and Experimental Groups

Groups compared	Mean score	Standard deviation	t-value	p-value
Experimental group	2.30	0.563	2.024394	0.842545
Control group	2.24	0.58		

P > 0.05 =non-significant

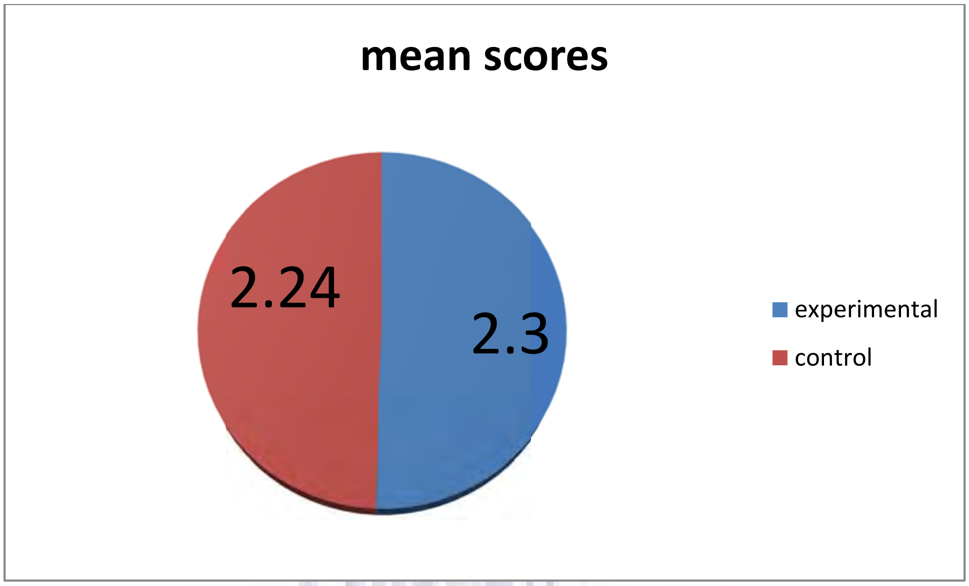

Figure 6: Groups' mean scores in the CSPATOC Questionnaire

To find out the extent of academic performance of students in the experimental group was significantly higher than the academic performance of students in the control chemistry class in classification and naming of organic compounds, the Research Question Two was stated as thus:

Research Question Two

1. To what extent is the academic performance of students in the experimental group significantly higher than students in the control chemistry class in classification and naming of organic compounds?

In order to address this research question, students were asked to indicate their responses to the test items OCCT (pre-test) and SKOCCT (post-test).

Descriptive statistics was used to find out the differences in the academic performance between the control and experimental groups in classifying and naming organic compounds. Means and standard deviations (SD) for pre and post tests were computed (table 3). The mean scores and standard deviations for experimental and control groups in the pre-test (OCCT) are respectively were 15.63 (SD = 4.127) and 13.54 (SD=3.037). The mean score in the pre-test for the experimental group was little higher than that of the control before the intervention. On the other hand, the mean scores and standard deviations for the experimental and control groups in the post test were respectively 20.92 (SD = 5.697) and 16.66 (SD = 5.906). In the post test (SKOCCT), the mean score of the experimental group was by far higher than the control group after the intervention.

Table 3: Independent t-test Analyses of Pre- (OCCT) and Post-test (SKOCCT)

Group	Test	Mean	Standard Deviation	T-value	P-value
Experimental	Pre test	15.63	4.127	1.99	0.020
Control	Pre test	13.54	3.037		
Experimental	Post test	20.93	5.697	1.98896	0.001
Control	Post test	16.66	5.906		

$P < 0.05$ = significant.

To determine whether there was any statistically significant difference in academic performance between the experimental group / jigsaw model and the control group / traditional chemistry class in classification and nomenclature of organic compounds, research question two was formulated into a null hypothesis.

Ho_2: There is no significant difference in academic performance of students in the jigsaw model group and the academic performance of students in the traditional chemistry class in classification and nomenclature of organic compounds.

A t- test was used in order to explore whether there were differences between the experimental/Jigsaw and control/ traditional chemistry group in terms of classification and nomenclature of organic compounds in both pre and post test scores (Table 3).

The t score (1.99) related to the differences between pre-test (OCCT) scores of the experimental and control group students was found to be significant ($p < 0.05$). This reveals that there is difference between experimental and control group students' OCCT pre-test scores in favour of the experimental group.

In the analysis of the table, the t score (1.99) related to the differences between the experimental and control group students' scores from post-test (SKOCCT) was found to be significant $p = 0.001$ ($p < 0.05$). This result shows that there is a significant difference between experimental and control group students in terms of their post-test (SKOCCT) scores. Again in the table, it can seen that the mean of post- test (SKOCCT) scores of the students in Jigsaw group was 20.92 and higher than the mean (M: 16.66) of the scores of non jigsaw (control) group students. As a result, it can be said that post- test (SKOCCT) scores of the students in Jigsaw group are higher than the scores of those in the control group. This indicated that the experimental group after the intervention had improved in their performance in naming and classification of organic compounds as compared to their counterparts in the control group though there were some improvements. Hence the null hypothesis (Ho_2) was rejected.

Figure 7 show the outcome of the means of the control and experimental groups in pre and post test.

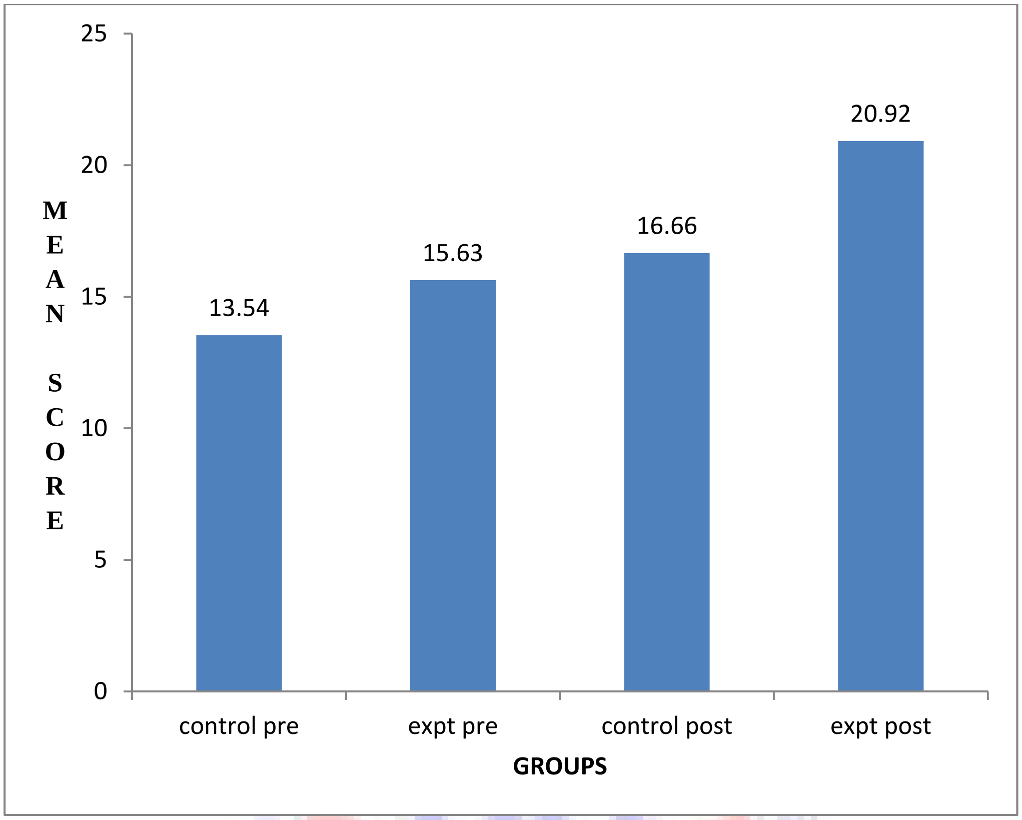

Figure 7: means of experimental and control groups in pre- and post- test

Research Question Three

To what extent is the retention of organic chemistry concept in the jigsaw model group significantly higher than the retention of students in the traditional chemistry group?

This research question in the study sought to gather information on the extent of retention of chemistry concepts by the two groups.

In order to address this research question, students were asked to indicate their responses to the delayed posttest items titled students' retention achievement test in organic chemistry (SRATOC). The result was also compared to post test (SKOCCT) of the control and experimental groups.

Descriptive statistics was used to find the difference in the retention of organic concept between the control and the experimental groups. Mean and standard deviation for both tests were computed (table 4). The mean scores and standard deviations of the post test-SKOCCT of the control and experimental groups were respectively 16.66 (SD = 5.906) and approximately 20.92 (SD = 5.697). As seen already the mean score of experimental group was higher than the control group after the intervention. However the mean scores and standard deviations of the SRATOC of the control and experimental groups were respectively 15.75 (SD = 5.54) and approximately 23.00 (SD = 5.494) table 4. The retention of the experimental group appeared to be better than the control group.

To determine whether there was significant difference between the control and the experimental groups in the retention of organic concepts, the research question three was formulated into a null hypothesis thus stated:

Ho_3: There is no statistically significant difference in the retention of classification and nomenclature of organic chemistry in the experimental group and students in the traditional group in the chemistry class.

Table 4: Independent t-Test Analyses of Post-test (SKOCCT) and delayed Post-test (SRATOC)

Test	**Mean Score**	**Standard Deviation**	**t**	**p**
Post test				
Control	16.66	5.906	1.99	0.0011
Experimental	20.92	5.697		
Delayed post test				
Control group	15.75	5.543	1.99	$6.48 * 10^{-08}$
Experimental group	23.00	5.494		

$P < 0.05$ = significant.

A t test was used in order to explore whether there were differences between the experimental/Jigsaw and control/ traditional chemistry group in terms of classification and nomenclature of organic compounds in both post test and delayed post test scores (Table 5).

The t test value pertaining to differences between the scores of experimental and control groups from the SRATOC retention test given to students 15 days after the post test was found to be significant at the level of 1.99 ($p < 0.05$). When the table is analyzed, it is clearly seen that the mean of the retention test scores of the experimental group is higher than that of the control group. These findings indicated that Jigsaw technique is more effective than the traditional instructional teacher-centered teaching method on both learning and retention. Therefore the null hypothesis (Ho_3) was rejected.

Research Question Four

What is the gender difference in performance of students in classifying and naming organic compounds using jigsaw method?

This research question of the study sought to gather information on the gender difference in performance in classification and naming organic compounds after the intervention.

Descriptive statistics was used to determine the differences in performance between male and female students in naming and classifying organic compound after the intervention. Mean and standard deviation for both tests was computed (table 5).

The mean score for the female in the pre-test was 15.067 (SD = 4.652) and the male counterparts was 15.293 (SD = 4.073) at a degree of freedom of 54. The mean score of the male in the pre-test was slightly above their female counterpart in the experimental group before the intervention. However, the result of the post test indicated that the female students appear to have done slightly above their male counterparts after the intervention. The mean and standard deviation of the male and female students in the post test were respectively 20.77 (SD = 6.039) and 21.60 (SD = 4.088) at a degree of freedom of 51.

To determine whether any significant difference existed between male and the female students in their performance in classification and nomenclature of organic compounds the research question four was formulated into a null hypothesis thus stated:

Ho_4. There is no statistically significant gender difference in the performance of students in classifying and naming organic compounds using jigsaw model.

Table 5: T test Analysis of Scores According to Gender in the Experimental Group

Gender	Mean	Standard Deviation	T- value	P-value	Degree of Freedom
Pre test					
Female	15.07	4.652	2.005	0.861	54
Male	15.293	4.073			
Post test					
Female	21.60	4.088	2.008	0.861	51
male	20.77	6.039			

P > 0.05 = non- significant

A t test was used in order to explore whether there were significant differences between male and female in terms of classification and nomenclature of organic compounds in both pretest and post test scores in the experimental group (Table 5).

The t test value pertaining to differences between the scores of female and male students from the pretest was found to be non- significant at the level of 2.005 (p > 0.05). This indicated that the two groups were similar in their entering behaviour before the intervention.

The female students appeared to have done better in the post test than their male counterparts after the intervention but the t-test analyses showed that there was no significant difference at the level of 2.008 ($p>0.05$) between the two groups. This implies that there was indeed, no significant difference between the mean scores of the two groups and consequently the test failed to reject the null hypothesis (Ho_4).

Discussions

One of the objectives of the study was to identify the differences in perception and attitude between the control and experimental groups towards organic chemistry's concepts specifically classification and nomenclature. Perception and attitude towards organic chemistry was generally positive. This finding provided empirical support to earlier finding such as Davis (2010) who studied senior secondary school students' and teachers' perception of the difficult organic chemistry topics in the Central Region of Ghana and observed that generally the S.S.S chemistry students' perception of the level of difficulty of organic chemistry topics was slightly positive ($5.97<X$). However, the findings of this study contradict the findings of some other researchers; for example the findings of Wood (1994) and Draphor (1994), who studied Senior Secondary School Students' perception of chemistry topics, indicated that chemistry students had difficulty with organic chemistry in general.

However there were slight differences between the control and the experimental groups comparing their mean; thus the control group had lower mean score (2.24) indicated that they had more positive attitude and perception than the experimental group with mean score of 2.30. This was because 1 and 2 were scored maximum point on the scale of measurement and overall mean less than 3.0 was set to be positive attitude and perception.

Results from Table 2 indicated that the perception and attitude of both groups were the same; since there were no significant differences between the control and experimental groups. This indicated that the control and experimental groups had the same entering behaviour before the intervention. This implied that the perceptions and attitudes towards organic chemistry of both groups before the study were similar.

When the students' performance in pre-test and post test was compared, it was revealed that in the pre test the experimental group had slightly higher mean than the control group. The difference between their mean was about 2.0 though significant, however in the post test the differences in their mean performance was about 4.26 which could be attributed to different mode of instruction used.

Results from Table 3 indicated that the jigsaw teaching method used had effects on the academic achievement of students in their groups at the post test level. There was significant difference in academic achievement of the students in the two treatment groups with jigsaw strategy having the highest positive effect, while conventional method had lowest positive effect. This result implies that the jigsaw cooperative learning strategies of teaching promoted students' understanding of organic concepts taught and improved their academic achievement more than the conventional lecture method even though there were some improvements in the control group taught with the conventional method. This finding provided empirical support to earlier findings: Johnson,Johnson and Zaindman, (1981); Fuyunyu, 1998; Popoola, (2002) and Omoshehin (2004) who established that cooperative learning strategy promoted better achievement and productivity than the conventional lecture method. This result is also in line with the findings of Burcin and Leman, (2007); Chang and Mao, (1999); Dimitrios, Andrens and Georgios. (2006); Pandian, (2004); Samuel and John, (2004), who reported in their different studies that cooperative learning strategies facilitated students' learning more than conventional lecture method.

However, the findings of this study contradict the findings of some other researchers who have reported no significant difference between the academic achievement of students in cooperative learning group and students in other groups - conventional lecture, competitive, and individualistic methods - (e.g. Chin-Chau, (1997); Chang and Mao, (1999); Lawrence, (2006); Martin and Roland, (2007); Rossini and Jim, (1997).

Students' retention ability in classification and nomenclature was observed among the control and experimental groups using the delayed post test. The result was compared to the post test result and realized that the control group had their posttest mean reduced (16.66 to 15.75) while the experimental group which was taught with jigsaw IV had their posttest increased in the delayed post test (20.92 to 23.00). This indicated that intervention had positive effect on student retention ability.

Results along retention line (Table 4) revealed that jigsaw strategies of cooperative learning aided students' retention of organic concepts taught (the students' scores at the delayed – posttest level were a little bit higher than their scores at the posttest level, their scores did not reduce), while conventional - lecture method did not aid students' retention of organic chemistry concepts (students' scores at the delayed – posttest level were lower than their scores at the posttest level). This result implies that the cooperative learning strategies brought about retention of organic chemistry concepts. This might be as a result of the active involvement of students in teaching and learning process. This result conforms to the findings of Dougherty et al. (1995); Rossini and Jim (1997).

Another objective of this study was to find out the gender differences in performance of students on classification and nomenclature of organic compounds after the intervention. In the fourth hypothesis (Table 5), it was discovered that there was no gender difference in the performance among female and male students in classification and nomenclature of organic compounds using the jigsaw teaching and learning technique. This was in consonance with the findings of previous researchers (Gardner, 1995; Miller, 2001; Ramayah, Syvanandan, Nasrijal, Letchumanan and Leong, 2009) who established that both male and female students exhibited a similar response towards learning style that adopted interactive methods. The result was also consistent with the findings of Leinhardt, Seewald and Engelra (1999), Akinbobola (2006; 2008), and Afolabi and Akinbobola (2009) that show no significant difference in the mean performance between boys and girls in the manipulation of the same instructional materials as well as in their rate of contribution and class participation. This finding is also in line with the findings of Adeleke (2007) who showed that there was no significant difference in problem solving performance between male and female students. However, the finding is in contrast with the findings of Ehindero et al (2009) in a study conducted in Nigeria. They concluded that girls have higher achievement scores than boys in logical reasoning, linguistic, reading and word-problem solving abilities.

Possible explanation for the result may be due to the fact that any good teaching approach does not discriminate between the sexes. The implication is that applying appropriate teaching approaches can help both male and female students learn and remember facts, apply skill, comprehend concepts, analyze and synthesize principles. Thus, students' attainments from a lesson depend on the mode of teaching method adopted by teacher and it does not matter whether one is a male or female.

Initially, a reasonable proportion of the students did not like to use the Jigsaw IV – this was somewhat of a surprise given reports in the literature that students generally enjoy practical work and more active learning strategies (Johnson & Johnson, 2005), and indeed cooperative learning strategies such as group work (Lazarowitz & Hertz-Lazarowitz, 1998). Here it was suggested there are two main reasons why these students might not have enjoyed Jigsaw as much as anticipated. First, is the educational context; namely the Ghanaian education system. Students are much more accustomed to passive learning in which the teacher gives clear directions and controls the learning environment. Whilst one might think this is more of an issue in school, Coll, Taylor and Fisher (2002) noted that this is also true even in higher education where students are expected to become more independent learners. However, Coll et al. (2002) reported that many students, especially academically-able students, prefer the teacher to exercise control over the classroom and learning activities, because this results in greater clarity about what is needed to be done to succeed in assessment tasks. According to Vulliamy as cited by Ninna, Ekasoth and Coll, (2008) commented that success in higher education in many developing countries is of high priority, as exams and test serve as gatekeepers for future careers.

Secondly, it is possible that the students did not really understand the purpose of the method. This is in fact, consistent with the literature, which suggests one common problem of cooperative learning methods lies in students actually understanding the processes, and roles of participants (Balfakih, 2003). If the purpose of the new approach is not made explicit, it seems students and indeed teachers may focus on the new activity and fail to grasp its purpose and thereby value in the learning process. This was no doubt exacerbated in the present work because the learning environment was so very different to what Ghanaian school students typically experience. In addition, some of the student participants felt they spent too much time when learning by the Jigsaw IV method, something the literature suggest is a common perceived barrier to new, particularly constructivist-based learning approaches, like the Jigsaw method (Colosi & Zales, 1998).

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

Overview

This chapter provides summary of the findings, conclusion and the recommendations with respect to the use of jigsaw cooperate model to enhance S.H.S chemistry students' performance in classification and nomenclature of organic compounds.

Summary

The problem that prompted this study was the consistent report by the Chief Examiner (WAEC), of poor performance in the organic chemistry section of the WASSCE chemistry paper by S.H.S chemistry students. This study was therefore designed to investigate students' attitude and perception toward organic chemistry concept. It also investigated whether there was a significant difference between control and experimental groups in their performance in organic chemistry concepts. There was also comparison between the experimental groups in the delayed post test to find out the retention ability between the groups.

The study further investigated whether there was any relationship between male chemistry students' performance in organic chemistry concept and that of their female counterpart after being taught with the jigsaw cooperative method. The study specifically sought to find answers to the four research questions and four hypotheses.

The study was carried out at the Sunyani Municipal in the Brong Ahafo Region of Ghana using the quasi-experimental with pretest, posttest and delayed post test methods. Ninety-four second year S.H.S students were conveniently selected. Questionnaire (CSPATOC) and test items (OCCT, SKOCCT and SRATOC) were administered and responded to by these 94 S.H.S second year chemistry students.

The data collected was analyzed using quantitative approach. The quantitative approach included the use of percentages and descriptive statistics, such as the mean and the standard deviations. T-test statistic was used to find out whether there was any significant difference between male and female students, control and experimental groups' perception, attitude and performance.

The purpose of the study was to use the jigsaw cooperative model to enhance Senior High School chemistry students' performance and retention in classification and nomenclature of organic chemistry.

From the analysis of the data in the study, the following were the major findings:

1. The findings indicated that generally, the perception and attitude of the respondents (S.H.S chemistry students) towards organic chemistry concept were positive and that there was no statistically significant difference between the control and experimental groups.
2. It was also realized that the use of jigsaw instrument enhanced or improved upon the academic performance of students in classification and nomenclature of organic compounds.
3. The study also indicated that the jigsaw technique is more effective on retention of organic concepts as compared to traditional conventional teaching methods. Thus, there was a significant difference statistically in retention of academic

materials between the control and experimental groups (taught with jigsaw cooperative model) in classification and nomenclature of organic compounds.

4. It was observed that there was no statistically significant difference in gender's performance in classification and nomenclature of organic compounds when taught with the jigsaw cooperative model. Thus, the jigsaw technique of teaching and learning as a good model does not show any disparities between sexes in their academic performance in organic concepts like classification and nomenclature.

Conclusion

After the analysis of the data, it was found that Jigsaw IV technique was more effective than instructional teacher centered teaching in the naming and classification of organic compounds of the students, in the experimental group.

Those home groups and expert groups in the experimental group provide activities that are rich in cooperation to teach the concepts, find solutions and suggestions which showed that Jigsaw technique is effective in terms of teaching content and atmosphere besides having positive effects on academic achievement. In addition, use of introduction, quizzes, re-teaching, and academic achievement tests in Jigsaw IV groups, expert groups also contributed to a complete understanding of the concepts. The results of the retention test conducted after few days of the intervention revealed that Jigsaw IV was effective on learning and retention of the organic concepts.

The superiority of Jigsaw cooperative learning strategy over the conventional technique could be attributed to the fact that it makes students develop more positive attitudes toward self, peer, adults and learning in general (Omoshehin, 2004). When friendliness is established, students are motivated to learn and are more confident to ask questions from one another for better understanding of the tasks being learnt. Also the jigsaw mode of learning makes the teacher to become co-learner, facilitator, guide and it also helps learners to obtain information to solve problems rather than being passive learners as in behavioural theory of learning.

Lastly, the jigsaw cooperative model takes care of individual differences during teaching and learning especially gender and different ability groups, therefore it is recommended to be used in teaching of organic chemistry concepts.

Recommendations

Based on the findings of the study, the following recommendations could be made;

1. Chemistry teachers at the Sunyani Municipality should embrace jigsaw cooperative model in their various secondary schools, since it helps students to get higher immediate and delayed academic achievement. This will also help to solve the problem of students withdrawing from the study of chemistry and performing poorly in internal and external examinations.
2. Jigsaw teaching and learning technique is capable of developing students' communicative and collaborative working skills and their skills on accessing information and utilizing it. Therefore it should be adopted as one of the basic methods of teaching organic chemistry in the Sunyani Municipality Senior High Schools.
3. Male and female students do not differ in their performance when using the jigsaw model instruction. It is therefore recommended that science departments in

our Senior High Schools especially the selected schools should always consider the interactive mode of learning such as jigsaw cooperative methods which include interaction, question and answer, assignment, quiz in their teaching methodology so that no student is disadvantaged by just approach use by the instructor.

4. It is necessary workshops and seminars are organized for practicing chemistry teachers in the municipalities to intimate them on the importance of jigsaw techniques for teaching and learning of chemistry especially organic chemistry since jigsaw IV cooperative teaching strategies and other various cooperative teaching strategies enhance students' academic achievement and retention in organic chemistry in particular and chemistry in general.
5. At the in-service level, seminars and workshops should be organized by Stakeholders of Education, such as Ghana Education Service, GAST, GNAT, NAGRAT etc. in order to educate practicing teachers on how to implement cooperative teaching strategy in schools at all levels of the Sunyani Municipality. This is because most teachers would not like to try any new method they are not accustomed with as suggested by Hume and Coll (2008) that any new teaching approach requires time for all parties (teachers, students etc.) to become accustomed to it before its full potential can be realized.

Suggestions for Future Research

1. It is suggested that the study should be conducted with a larger representative sample in Junior and Senior High schools in Ghana to assess the effectiveness of

the jigsaw cooperative model in teaching and learning science in general and chemistry in particular.

2. Teachers play an important role in the development of their students; therefore other researchers could also consider assessing the perception and attitude of Pre-Service teachers in Ghana towards the use of jigsaw in teaching chemistry concepts in organic or inorganic chemistry.
3. More work could be done on the analyses of learning outcome in chemistry among S.H.S Students' in urban and rural setting using jigsaw technique.

REFERENCES

Abdalla, M. I. (1991). An evaluation of first year practical chemistry in Jordanian Universities. Doctoral dissertation, University of East Anglia. *Dissertation Abstracts International, 52 (1),* 1A - 318A.

Abdullah, S. (2010). Effect of Jigsaw II Technique on Academic Achievement and Attitude to Written Expression Course, *Education Research and View, 5*(12), 777-787.

Abimbade, A. (1983). *The relative effectiveness of programmed instruction to the Traditional teaching of secondary mathematics.* Unpublished M.Ed Dissertation, University of Ibadan.

Adediwura, A. A., & Tayo, B. (2007). Perception of teachers' knowledge, attitude and teaching skills as predictor of academic performance in Nigerian secondary schools. *Educational Research and Review, 2* (7), 165-171.

Adeleke, M. A. (2007). Gender disparity in mathematical performance revisited: Can training in problem solving bring difference between boys and girls? *Essays in education online journal. R*etrieved September 8, 2012 from http/www.usca.edu/Essays.

Adeyemi, S. B. (2002*). Relative effects of cooperative and individualistic learning strategies on students' declarative and procedural knowledge in map work in Osun state,* Ph.D. Thesis. Ibadan: Dept. of Teacher Education, University of Ibadan.

Afolabi, F., & Akinbobola. A. O. (2009). Constructivist problem based learning techniques and the academic achievement of physics students with low ability level in Nigerian Secondary Schools. *Eurasian Journal of Physics and Chemistry Education, 1* (1), 45-51.

Aiyelaagbe, G. O. (1998). *The effectiveness of audio, visual and audio-visual self-learning packages in adult learning outcomes in basic literacy skills in Ibadan.* Unpublished Ph. D. Thesis, University of Ibadan.

Ajelabi, P. A. (1998). *The relative effectiveness of computer assisted and text – assisted programmed Instruction on students' learning outcomes in social studies*. Ph. D. Thesis. Department of Teacher Education, University of Ibadan.

Akinbobola, A. O. (2006). *Effects of teaching methods and study habits on students' achievement in senior secondary school physics: using pictorial organizers.* Unpublished PhD Dissertation, Uyo, Nigeria, University of Uyo,

Akinbobola, A .O. (2008). Facilitating Nigerian physics students' attitude towards the concept of heat energy. *Scientia Pedagogical Eperimentalis, 155*(2), 353-366.

Akinbobola, A. O., & Ado, I. B. (2007). Hands-on and minds-on strategies for teaching of force: Guided discovery approach. In E. Udo, U. Uyaota, N.E.U. Iyang, H. Yero, G. Bello (Eds.). *Proceeding of the Science Teachers Association of Nigeria (STAN) primary science workshop.* Uyo: Afahaide & Bros. Printing & Publishing Co.

Akinbode, M. B. (2006). *The relative effect of two instructional strategies on Senior Secondary School students' learning outcome in Islamic studies*. Ph. *D.* Thesis. Institute of Education, Ibadan: University of Ibadan.

Akinlaye, F. A. (1998). *Teacher directed inquiry, guided discussion and students' learning outcomes in some aspects of social studies*. Ph.D. Thesis. Department of Teacher Education, Ibadan: University of Ibadan.

Akinmade, C. T. O. (1992). Attitude to science as a school subject. In O. E Akpan (Ed.), *Toward creative science teaching and learning in West African Schools.* Cape Coast: Catholic Mission Press, 75-83.

Alebiosu, K. A. (1998). *Effects of two cooperative learning models on Senior Secondary School students' learning outcomes in chemistry*. Ph.D. Thesis. Dept. of Teacher Education, Ibadan, Nigeria: University of Ibadan.

Alexander, R. (1992). *Policy and practice in primary education*. London: Routledge

Allport, G. W. (1968). *Pattern and growth in personality.* London: William Clowes and Sons Ltd.

American Heritage Dictionary of the English Language, (5th ed.).(2011). Houghton Mifflin Company.

Amoah, S. A., & Onivehu, A. B. (2002). *Essentials in assessment.* Accra: R and B Publishers.

Amoo, S. A., & Rahman, M. A. (2004). Secondary school students' attitudes to learning mathematics in the world of information technology. Implication for mathematics teachers and teacher preparation. *In Proceeding of the 42nd Annual Conference of the Science Teachers Association of Nigeria*, Ibadan: Heinemann, 178-182

Ampiah, J. G. (2001). Students' perception of topics in senior secondary school chemistry syllabus. *Journal of Educational Development, 1* (1), 85-93.

Anamuah-Mensah, J. (1995). Ordinary Level chemistry topics: What students find difficult. *Journal of Oguaa Educator, 11* (2), 8-18.

Anamuah-Mensah, J. (1989). A perspective on Science education in Ghana. *Journal of Ghana Association of Science Teachers*, *1*, 14-15.

Anamuah-Mensah, J., & Apafo, N. T. (1986). Students' perceived difficulties with ordinary level chemistry topics. *Chemistry and Industry Proceedings,* 38-39.

Anderson, G., & Benjamin, D. (1994).The determinants of success in university introductory economics courses. *Journal of Economic Education, 25 (2),* 99 – 119.

Anderson, C. W. (1987). *Learning and Problem Solving with Multilayer Connectionist Systems*. Ph.D. thesis, University of Massachusetts, Amherst, MA.

Anderson, R. D. (2002). Reforming science teaching: What research says about inquiry. *J. Science Teacher Education, 13* (1), 1-12.

Anderson, R., & Miller, C. (1994). Research on science teacher education. In D. Gabel (Ed). *Hand on research on science teaching and learning*. New York: McMillan, 45-93.

Andrini, B. (1991). *Cooperative learning & mathematics: A multi-structural approach*: *Kagan cooperative learning*, CA: San Juan Capistrano.

Aripin, R., Mahmood, Z., Rohaizad, R., Yeop, U., & Anuar, M. (2008). Students' learning styles and academic performance. *22nd Annual SAS Malaysia Forum*, Kuala Lumpur Convention, Malaysia.

Aronson, E., & Patnoe, S. (1997). *The jigsaw classroom: Building cooperation in the classroom*. New York: Addison Wesley Longman.

Aronson, E., Blaney, N., Stephin, C., Sikes, J. & Snapp, M. (1978). *The Jigsaw Classroom*. Beverly Hills, CA: Sage Publishing Company

Ary, D. J., Jacobs, L., & Razzavieh, A. (2002). *Introduction to research in education.* Forth Worth: Holt, Reneheart & Winston Inc.

Audi, R. (1999). *Cambridge dictionary of philosophy*. Cambridge: Cambridge University Press.

Ayers, W. (1993). *To teac*h. New York. Teachers College Press. Retrieved from www.wofford.edu/education/conceptual framework.

Bahrick, H. P., & Hall, L. K. (1991). Lifetime maintenance of high school mathematics content. *Journal of Experiment Psychology, 120*, 20-33.

Bahrick, H. P. (1979). Maintenance of Knowledge: Questions about memory use forget to ask. *Journal of Experimental Psychology.108*, 296-308.

Bahrick, H. P. (1984). Semantic memory content in permastore: fifty years of memory for Spanish learned in school. *Journal of Experimental Psychology*, *113*. 1-29.

Balfakih, N. M. A. (2003). The effectiveness of student team-achievement division (STAD) for teaching high school chemistry in the United Arab Emirates. *International Journal of Science Education, 25 (*5*),* 605-624.

Bandura, A., & Schunk, D. H. (1981). Cultivating competence, self-efficacy, and intrinsic interest through proximal self-motivation. *Journal of Personality and Social Psychology*, *41*, 586-598.

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory.* Englewood Cliffs, NJ: Prentice Hall.

Bandura, A. (1997). *Self-efficacy: The exercise of control.* New York: Freeman.

Barbosa, R., Jofili, Z., & Watts, M. (2004). Cooperating in constructing knowledge: Case studies from chemistry and citizenship. *International Journal of Science Education, 26 (*8*), 935-949*.

Barne, N., & Dori, Y. J. (1996). Computerized molecular modelling as a tool to improve chemistry teaching. *Journal of Chemical Information and Computer Science, 36* (6), 629–636.

Barrass, R. (1984). Some Misconceptions and Misunderstandings Perpetuated by Teachers and Textbooks of Biology. *Journal of Biology Education* 18, 201-205

Barrett, T. (2005). Effects of Cooperative Learning on the Performance of Sixth- Grade Physical Education Students, *Journal of Physical Education, 24,* 88-102.

Beller, M., & Gafni, N. (2000). The International Assessment of Educational Progress in Mathematics and Sciences: The Gender Difference Perspective. *Journal of Educational Psychology. 88* (2), 365 – 377.

Best, J. W., & Kahn, J. V. (1989). *Research in education*. New Delhi: Pergamon Press.

Betiku, O. F. (2002). Cognitive styles and academic performance in Chemistry. *The Nigerian Teacher Today*. *10* (2), 37-52.

Blickenstaff, J. C. (2005*).* Women and science careers: Leaky pipeline or gender filter? *Gender and Education*, *17* (4*)*, 369-386.

Bligh, D. A. (2000). *What's the use of lectures*? San Francisco: Jossey–Bass.

Bogdan, R .C., & Biklen, S. K. (2003). *Qualitative research in education: An introductory to theory and methods*. Boston: Pearson Education Group, Inc.

Boli, J., Allen, M. L., & Payne, A. (1985). High-ability women and men in undergraduate mathematics and chemistry courses. *American Educational Research Journal*, *22* (4), 605-626.

Booth, S. (2001). Learning computer science and engineering in context. *Computer Science Education*, *11* (3), 169-188.

Borger, R., & Seaborne, A. (1966). *The Psychology of Learning.* Harmondsworth, Middlesex, England: Penguin.

Boujaoude, S., & Barakat, H. (2000). Secondary school students' difficulties with stoichiometry. *School Science Review, 81*, 91 -98.

Bransford, J. D., Brown, A. L., & Cocking, R. R. (2000). *How people learn: Brain, mind, experience, and school*. Washington, D. C: National Academy Press.

Brown, G. T. L. (2004). Teachers' Conceptions of Assessment Implications for Policy and Professional Development. *Assessment in Education: Principles, Policy and Practice, 11* (3), 301-318.

Brunning, R., Schraw, G., & Ronning, R. (1999). *Cognitive psychology and instruction.* (3rd Ed.). Upper Saddle River NJ: Prentice Hall.

Buccheri, G., Gurber, N., & Bruhwiler, C. (2011). The impact of gender on interest in science topics and the choice of scientific and technical vocations. *International Journal of Science Education, 33* (1), 159-178.

Burcin, A, & Leman, T. (2007). Effect of cooperative learning strategies on students' understanding of concepts in electro-chemistry. *International Journal of Science and mathematics Education, 5* (2), 349-373.

Burns, J. (2001). Encouraging girls and women in science: Getting going in Willington, New Zealand. In Daniels, J. & Khale, J.B. (Eds).*Contributions to the 45 GASAT conferences*: *GASAT*, *4* (2), 266 – 273.

Campbell, D. T., & Stanley, J. (1963). Experimental and quasi-experimental designs for research on teaching. In N. Gage (ed.). *Handbook of Research on Teaching* (pp.171- 246). Chicago: Rand McNally.

Carter, C. S., & Brickhouse, N. W. (1989). What makes chemistry difficult? Alternate perceptions. *Journal of Chemical Education, 66*, 223–225.

Chang, C. Y., & Mao, S. L. (1999). The effect of students' cognitive achievement when using the cooperative method in earth science classrooms. *Journal of School Science and Mathematics*, *99 (*7), 374-379.

Charania, N., Kausar, F., & Cassum, S. (2001). Playing jigsaw: A cooperative learning experience. *Journal of Nursing Education, 40* (9), 420-421.

Chin-Chau, L. (1997). *Effect of goal structure on Chinese elementary school students' goal orientation, achievement, intrinsic motivation and beliefs about success/failure.* Texas*:* Texas Technology University Libraries.

Chiu, M. H. (2004). An investigation of exploring mental models and causes of secondary school students' misconceptions in acids-bases, particle theory, and chemical equilibrium. *Annual report to National Science Council in Taiwan* (in Chinese).

Coll, R., Taylor, N., & Fisher, D. (2002). An application of the questionnaire on teacher interaction and college and university classroom environment inventory in a multicultural tertiary context. *Research in Science and Technological Education, 20*(2), 165-183.

Colosi, J. C., & Zales, C. R. (1998). Jigsaw cooperative learning improves biology lab courses. *Bioscience*, *48*(2), 118-124.

Conway, M. A., Cohen, G., & Stanhope, N. (1991). Very long-term memory of knowledge acquired at school and university. *Applied Cognitive Psychology*, 6, 467-482.

Cooper, I. L. & Greiner, J. M. (1971). Contingency management in an introductory psychology course produces better retention. *Psychological Record*, 21, 391-400

Copolo, C. F., & HounshelL, P. B. (1995). Using three-dimensional models to teach molecular structures in high school chemistry. *Journal of Science Education and Technology*, *4* (3), 295–305.

Creswell, J. W. (2009). *Research design, qualitative, quantitative, and mixed methods approaches*, (3rd Ed.). Thousand Oaks: CA. Sage Publications.

Dajili, A. O. A. (2001). *Handbook on educational psychology: theories and practice*. Ilorin: Decency Printers.

Daintith, J. (1981). *Dictionary of chemistry.* London: Intercontinental Book Productions Limited.

Darling-Hammond, L. (2001). The challenge of staffing our schools. *Educational Leadership*, *58* (8), 12-17.

Davis , G. (2010). *Senior secondary school students' and teachers' perception of the difficult organic chemistry topics in the central region.* M.Phil. Thesis. Dept. of Science and Mathematics Education, University of Cape Coast.

Denzin, N. K., & Lincoln, Y. S. (2000). *Handbook of qualitative research*. Thousand Oaks, CA: Sage Publications Inc.

Devadoss, S., & Foltz, J. (1996). Evaluation of factors influencing students attendance and performance. *American Journal of Agricultural Economics, 78 (*3*),* 499 – 507.

Devine, T. G., & Meagher, L. D. (1989). *Mastering study skills: a students' guide*. New: Prentice-Hall Inc.

Dimitrios, S., Andreas, D., & Georgios, T. (2006). A study of group interaction processes in lower secondary physics. *Journal of Research in Science Teaching, 43* (6), 556-576.

Doğru, M., & Kalender, S. (2007). "Applying the subject 'cell' through constructivist approach during science lessons and the teacher's view". *Journal of Environmental & Science Education, 2* (1), 3–13.

Dougherty, R. C., Bowen, C. W., Berger, T., Rees, W., Mellon, E. K., & Pulliam, E. (1995). Cooperative learning and enhanced communication, effects on student performance, retention, and attitudes in general chemistry. *Journal of Chemical Education*, *72*, 793-797.

Draphor, S. E. (1994). *Ghanaian senior secondary school student' perception of Chemistry topics*. Unpublished PGDE dissertation. Cape Coast: University of Cape Coast.

Driver, R., & Easley, J. (1978). Pupils and paradigms: A review of literature related the concept development in adolescent science students. *Studies in Science Education, 5*, 61–84.

Driver, R., & Erickson, G. (1983). Theories-in-action: some theoretical and empirical issues in the study of students' conceptual frameworks in science. *Studies in Science Education*, *10*, 37–60.

Duffy, T. M., Jonassen, D. H. (1991). Constructivism: New implications for instructional technology? *Educational Technology, 5,* 2-11

Dusick, D. M. (2011). *Writing the Delimitations*. Retrieved October 5, 2012 from http://bold-ed.com/delimitations.htm

Eggen, P., & Kauchak, D. (2001). *Educational psychology: Windows on classrooms.* New Jersey: Prentice Hall Inc.

Ehindero, O. J., & Ajibade, Y.A. (2000). What our student say about how we teach. *Ife Journal of Education Studies*, *7* (1), 1-9.

Ehindero, O. J., Adeleke, M. A., Oloyede, E. O. & Ajibade, Y.A. (2009). Looking at gender disparity in science and mathematics from other angles: are there differences in logical reasoning and linguistic abilities? *African Journal of Educational Studies in Mathematics and Science, 7*(3), 35-43.

Eilks, I. (2005). Experiences and reflections about teaching atomic structure in a jigsaw classroom in lower secondary school chemistry lessons. *Journal of Chemical Education*, *82* (2), 313–319.

Esan, A. O. (1999*). Effects of cooperative and individualistic problem-solving strategies on students' learning outcomes in secondary school mathematics.* Ph.D. Thesis. Dept. of Teacher Education. Ibadan*:* University of Ibadan.

Ezeliora, B. (2004). Motivating secondary school science teachers to face the challenges of the third millennium. *Journal of Science Teachers Association of Nigerian, 9*(2). 82- 88. .

Farr, M. J. (1987). *The long-term retention of knowledge and skills: a cognitive and instructional approach*. New York: Springer-Verlag.

Fazio, R. H., & Roskes, D. (1994). Acting as we feel: When and how attitudes guide behaviour. In S. Shavitt, & T. C. Brock (Eds.), *Persuasion*, (pp. 71-93). Boston: Allyn & Bacon.

Felder, R. M. (1993). Reaching the second tier: learning and teaching styles in college science education. *Journal of College Science Teaching, 23 (*5), 286 – 290.

Fleming, N. D. (1995), I'm different; not dumb. Modes of presentation (VARK) in the tertiary classroom. In A. Zelmer, (Ed.) Research and Development in Higher Education, *Proceedings of the 1995 Annual Conference of the Higher Education and Research Development Society of Australasia , HERDSA, 18,* 308 – 313

Fennema, E., & Frank, M. L. (1992).Teachers' knowledge and its impact. In: D. A. Grouws (Ed.). Handbook of research on mathematics teaching and learning. *A project of the National Council of Teachers of Mathematics.* New York: Macmillan Publishing Company.

Festus, C. (2007). Towards effective learning for learners: Tower gate resources, Port-Harcourt. Nigeria

Fleer, M. (1999). Children's alternative views: alternative to what? *International Journal of Science Education, 21*, 119–135.

Ford, D. S. (1985). Self-concept and perception of school atmosphere among senior high school students. *Journal of Negro Education, 71*, 289-296.

Francisco, J., Nicoll, G. & Trautmann, M. (1998). Integrating multiple teaching methods into a general chemistry classroom. *Journal of Chemical Education*, *75*, 201- 213.

Fuyunyu, Y. (1998). The effects of cooperation with inter-group competition on performance and attitudes in a computer assisted science instruction. *Journal of Computers in Mathematics and Science Teaching, 17*(4), 381 – 395.

Gabel, D. (1999). Improving teaching and learning through chemistry education Research: A look to the future. *Journal of Chemical Education, 76*, 548-554.

Gabel, D. L., & Bunce, D. M. (1994). Research on problem solving: chemistry. In D. Gabel (Ed.), *Handbook of research on science teaching and learning.* NewYork: Macmillan Publishing Company. pp. 301–316.

Gado, I., Verma, G., & Simonis, D. (2004). *Middle grade teachers' perception of their chemistry efficacy: findings of a one year long professional development program.* Retrieved December13,2012 from (www.http://coefaculty.valdosta.edu/1schmert/gera/volume6/final %20verma.pdf)

Gamoran, A., Secoda, W. G,. & Marrett, C.A. (1998). *The organisational context of teaching and learning: Changing theoretical perspectives*, In Hallinan, M.T.(eds). Handbook of Sociology of Education.

Gardner, J. W. (1995). Learning styles: Implications for distance learning. *New direction in Adult Continuing Education, 67*, 19-32.

Glasersfield, E. (1989). Cognition, construction of knowledge, and teaching. *Syntheses, 80* (1), 121 – 140.

Glasnapp, D. R., Poggio, J. P., & Ory, J. C. (1978). End-of-course and long-term retention outcomes for mastery and non mastery learning paradigms. *Psychology in the Schools, 15*, 595-603.

Gonzalez, A., & Guerrero, M. (1983). *Jigsaw teacher's handbook*. Hollister, CA: Hollister Unified School District.

Gonzalez, F. M. (1997). Diagnosis of Spanish primary school students' common alternative science conceptions. *School Science and Mathematics, 97* (2), 68-74.

Good, T. L., Brophy, J. E. (1990). *Educational psychology: A realistic approach.* (4th ed.). White Plains, NY: Longman.

Hackett, G., & Betz, N. E. (1989). An exploration of the mathematics self-efficacy/ mathematics performance correspondence. *Journal for Research in Mathematics Education, 20*, 261-273.

Hallinan, T. M., Bottoms, E., Pallas, M. A., & Palla, M. A. (2003). Ability grouping and students learning. *Brookings Papers on Education Policy, 6*, 95-140

Hancock, C. H. (1940). An evaluation of certain popular science misconceptions. *Science Education, 24*, 208-213.

Harb, N., & El-Shaarawi, A. (2006). *Factors affecting student performance.* Munich Personal RePEc Archive Paper No. 13621. Accessed on November 02, 2012 from http://mpra.ub.uni-muenchen.de/13621/

Harlen, W. (1999). *Effective teaching of science: A review of research*. Research series . Scoutish Council for Research in Education. ERIC Reproductive Service ED, 431-772.

Harman, G., & Nguyen, T. N. (2010). Reforming teaching and learning in vietnam's higher education system. In G. Haaland, M. Hayden & T. Nghi (Eds.), *Reforming Higher Education in Vietnam: Challenges and Priorities* (pp.65-86). London: Springer

Hassan, A. K., Hill, R. A., & Reid, N. (2004). Ideas underpinning success in an introductory course in organic chemistry. *The Royal Society of Education, 8*, 40-51.

Hennessy, D., & Evans, R. (2006). Small-group learning in the community college classroom. *The Community College Enterprise, 12*(1), 93–109.

Herron, J. D. (1996). *The chemistry classroom: formulas for successful teaching*. Washington, DC: American Chemical Society.

Higbee, K. L. (1977). *Your memory: How it works and how to improve it*. Englewood Cliffs, NJ: Prentice Hall.

Hmelo-Silver, Duncan, & Chinn (2007). Scaffolding and achievement in problem-based and inquiry learning: A response to Kirschner, Sweller, and Clark (2006). *Educational Psychologist, 42* (2), 99–107.

Hodson, A. 1999). Relevant Physics for everyone: Teaching societal topics in introductory physics. *International Journal of Science Education, 14*(5), 541-562.

Holliday, D. C. (2002). Jigsaw IV: Using student/teacher concerns to improve jigsaw III. *ERIC*. ED 465687.

Holliday, D. C. (2000).The development of jigsaw IV in a secondary social studies classroom. *Paper presented at the 2000 Midwest Educational Research Association (MWERA)*. Annual Conference in Chicago, IL.

Holt, D. G., & Willard-Holt, C. (2000). Lets get real – students solving authentic corporate problems. *Phi Defta Kappan, 82* (3), 125-134.

Honebein, P. C. (1996). Seven goals for the design of constructivist learning environments. In Wilson, B. G. (Ed). *Constructivist learning environments: case studies in instructional design*. Educational Technology Publications Englewood Cliffs, New Jersey

Hume, A., & Coll, R. K. (2008). Student experiences of carrying out a practical science investigation under direction. *International Journal of Science Education, 30* (9), 1201-1228.

Hurd, P. D. (2002). Modernizing science education. *Journal of Research in Science Teaching, 39*, 3- 9.

Johnson, D. J. (1990). Teachers' job-related stress. *Journal of Instruction Psychology, 17* (1), 11-18.

Johnson, D. W., & Johnson, R. T. (2005). Learning groups. In S. A. Wheelan (Ed.). *The handbook of group research and practice* .Thousand Oaks, CA: Sage .

Johnson, D. W., Johnson, R. T., & Holubec, E. J. (1993). *Cooperation in the classroom* (6th ed.). Edina, MN: Interaction Book Company.

Johnson, D. W., Johnson, R. T., & Smith, K. A. (1998). *Active learning: Cooperation in the college classroom*, (2nd ed.); Interaction Book: Edina, MN.

Johnson, D. W., Johnson, R. T., & Zaindman, B. (1981). Oral interaction in cooperative learning groups: speaking, listening and nature statements made by high, medium and low achieving students. *Journal of Psychology, 119*, 303 – 321.

Johnson, M., & Ward, P. (2001). Effects of class wide peer tutoring on correct performance of striking skills in 3rd grade physical education, *Journal of Teaching Physical Educ*ation, 20, 247-263.

Johnstone, A. H., & Letton, K. M. (1990). Investigating undergraduate laboratory work. *Education in Chemistry*, *27* (1), 9–11.

Johnstone, A. (1984). New star for the teacher to steer by. *Journal of Chemical Education, 61* (10), 847-849.

Jonassen, D. H. (1991). Objectivism versus constructivism: do we need a new philosophical paradigm? *Educational Technology Research and Development, 39* (3), 5-14.

Jonasson, D.H. (1991). Thinking technology: Toward a constructivist design model. [On-line]. Available: http://ouray.cudenver.edu/~slsanfor/cnstdm.txt

Joppe, M. (2000). *The research process.* Retrieved June 11th, 2012 from http://www.ryerson.ca/~mjoppe/rp.htm.

Jordan, A., Carlile, O., & Stack, A. (2008). *Approaches to learning: a guide for teachers*. Maidenhead: Open University Press.

Killen, R. (2007). *Effective teaching strategies: lessons from research and practice* (4th ed.). Melbourne: Thompson Social Sciences Press.

Kim, L. (2005). The effects of a constructivist teaching approach on student academic achievement, self-concept, and learning strategies. *Asia Pacific Education Review, 6* (1), 719.

Kirschner, P. A., Sweller, J., & Clark, R. E. (2006). Why minimal guidance during instruction does not work: an analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching. *Educational Psychologist, 41* (2), 75–86.

Kliebard, H. (1992). Constructing a history of American curriculum in handbook of research on curriculum. The Tyler rationale. *School Review* .78 (2), 157–184.

Knapper, C. K., & Cropley, A. J. (1985). *Lifelong learning and higher education*. London: Rutledge.

Knight, J. K., & Wood, W. B. (2005). Teaching more by lecturing less. *Cell Biology Education, 4,* 298-310.

Kozma, R. B., Russell, J., Jones, T., Marx, N., & Davis, J. (1996). The use of multiple, linked representations to facilitate science understanding. In R. G. S. Vosniadou, E. DeCorte, & H. Mandel (Eds.), *International perspective on the psychological foundations of technology-based learning environments*. Hillsdale, NJ: Erlbaum, pp. 41–60.

Kraft, R. (1994). *Teaching and learning in Ghana: A curriculum, textbooks, syllabus and handbook analysis.* A report submitted to the Agency for international Development USAID Mission in Accra, Ghana.

Krajcik, J. S., Simmons, P. E., & Lunetta, V. N. (1988). A research strategy for the dynamic study of students' concepts and problem solving strategies using science software. *Journal of Research in Science Teaching*, *25* (2), 147–155.

Kuyper, H., Van der Werf, G., & Bosker, R. (2011). Who succeeds in advanced mathematics and science courses? *British Educational Research Journal, 37* (3), 357-380.

Lawrence, W. S. (2006). A Comparative study of cooperative and competitive achievement in two secondary biology classrooms: The group investigation model versus an individually competitive goal structure. *Journal of Research in Science Teaching*, *26* (1*)*, 55-64.

Lazarowitz, R., & Hertz-Lazarowitz, R. (1998). Cooperative learning in the science curriculum, In B. J. Fraser & K. G. Tobin (Eds.), *International handbook of science education, 5(*23*)*, 449-469.

Leedy, P. (1993). *Practical research: planning and designing* (5th.ed.). New York. Macmillan Publishing Company.

Leinhardt, G., Seewald, A., & Engelra, B. (1999). Learning what is taught: sex difference in instructions: *Journal of Educational Psychology, 60 (24), 90.*

Liebert, V .C. (1992). Male, Female, and the Higher Learning: The Educational Significance of Differences between the Sexes, *Journal of Higher Education, 30*, 67-72.

Longman Dictionary of Language Teaching and Applied Linguistics (1998). Longman Group Limited. U.K.

Lord, T. R. (1999). A comparison between traditional and constructivist teaching in environmental science. *Journal of Environmental Education*, 30, (*3*), 22-28.

Macmillan, J. J. (1996). *Educational research: Fundamentals for the consumer* (2nd ed.). New York: Harper Collins College.

Mahaja, D. S., & Singh, G. S. (2004). *Phobia towards organic chemistry in year one students at the University of Botswana*. Lonaka: Bulletin of the Center for Academic Development. University of Botswana.

Marshall, A. P. (1980).*Your guide to examination success*. London: Evans Brothers Ltd.

Martin, H., & Roland, B. (2007). Cooperative learning, motivational effect, and student characteristics: An experimental study comparing cooperative learning and direct instruction in 12th grade physics classes. *Educational Resources Information Centre*.

Marzano, R. J. (2003). *What works in schools: Translating research into action?* Retrieved from http://pdonline.ascd.org/pd_online/whatworks/marzano2003_ch13.html

Mathews, J. (1989). *Curriculum exposed*. London: David Fulton Publishers Ltd.

McDiamind, C., & Anderson, R. (1989).Teacher's perspective; developing and improving curriculum. *Journal of Research in Science*, *26*, 351 – 369.

Microsoft Encarta. (2009). *Microsoft Encarta college dictionary*. New York, NY: St.

Miller P. (2001). Learning styles: the multimedia of the mind. *Education Resources Information Centre, 451*, 140.

Merrill, M. D. (1991). Constructivism and instructional design. *Educational Technology 4* , 45-53.

Nakhleh, M. B. (1992). Why some students don't learn chemistry. *Journal of Chemical Education*, *69*, 191-196.

Neuschmidt, O., Barth, J., & Hastedt, D. (2008). Trends in gender differences in mathematics and science (TIMSS 1995-2003). *Studies in Educational Evaluation*, *34*, 56-72.

Ninna, J., Ekasoth, S., & Coll, R. (2008). Thai Undergraduate Chemistry Practical Learning Experiences Using the Jigsaw IV Method. *Journal of Science and Mathematics Education in South East Asia*, *31* (2), 178-200

Ojerinde, A. (1981). *Birth order and academic achievement.* A Seminar Paper presented at the Department of Educational Foundations and Counseling, University of Ife, Nigeria.

Ojo, O. M. (1989). *The differential effectiveness of cooperative, competitive and individualistic goal structures on students' performance in chemistry*. Ph.D. Thesis. Dept. of Teacher Education. Ibadan: University of Ibadan.

Okebukonla, P. A. O. (1984). *Effects of cooperative competitive and individualistic laboratory interaction pattern on students performance in biology.* Unpublished Ph.D. thesis, Ibadan: University of Ibadan.

Okebukola, P. A. (1985). *Effect of Cooperative, Competitive and Individualistic Laboratory Interaction Pattern on Students' Performance in Biology.* Unpublished Ph.D Thesis. Ibadan, Nigeria: University of Ibadan.

Okeke, E. A. C. (2002). *Gender, science and technology for Africa. A challenge for education.* The 2000 Rama mental lecture. Radcliffe College.

Okeke, B., & Ezekannagba, C. N. (2000). Chemistry education in the science of formality for sustainable development. *43rd Annual Science Teachers Association of Nigeria (STAN) Conference Proceedings*, 270-273.

Okoli, J. N. (2006). Effects of investigative laboratory approach and expository methods on acquisition of science process skills by biology students of different levels of scientific literacy. *Journal of Science Teachers Association of Nigeria, 41* (2). 79- 88.

Okou, J. A. (1991). Gender and Academic Specialties: Trends among Recipients of College Degrees in the 1980s. *Journal of Sociology of Education, 68*, 81-98.

Okunlola, P. O. (1985*). Resources and resources utilization as correlates of school academic performance in the secondary pre-vocational education in Ogun State.* An unpublished Ph.D thesis. Nigeria: University of Ibadan.

Olatoye, R. A., & Adekoya, Y. M. (2009). Effect of four teaching strategies on senior secondary school students' achievement in an aspect of agricultural science. *African Journal of Educational Studies in Mathematics and Science*. *7*, 1-16.

Omoshehin, M. F. (2004*). Effects of a training programme in cooperative learning of pre-service teachers' classroom practice and pupils learning outcomes in social studies*. Ph.D. Thesis .Dept. of Teacher Education. University of Ibadan, Ibadan.

Omrod, J. E. (2008). *Educational psychology: developing learners.* Sixth Edition. Upper Saddle River, New Jersey: Pearson Education

Osuala, E. C. (1993). *Introduction to research methodology*. Onitsha: African FED Publishers.

Oversby, J. (2000). Models in explanations of chemistry: The case of acidity. In J. K. Gilbert & C. J. Boulter (Eds.). *Developing Models in Science Education*, (pp.227-251), London: Kluwer.

Oyedeji, O. A. (1992). Areas of difficulties in primary mathematics curriculum as perceived by in service Mathematics teachers. *Journal of Science Teachers Association of Nigeria, 26* (2), 66- 70.

Pandian, S. S. (2004). *Cooperative learning in Biology: The effect of computers.* Department of Education, Arunachi University, India.

Pashler, H., McDaniel, M., Rohrer, D., & Bjork, R. (2008). Learning styles: Concepts and evidence. *Psychological Science in the Public Interest*, 9, 105-119

Patton, M. Q. (2002). *Qualitative research and evaluation methods.* Thousand Oaks, California: Sage Publications Inc.

Patton, M. Q. (2007*). Qualitative research and evaluation methods* (7th ed). London: Sage Publications, Inc.

Piaget, J. (1945). *Play, dreams and imitation in childhood*. London: Heinemann

Piaget, J., & Inhelder, B. (1969). The Psychology of the child. New York: Basic Books, Inc. Vygotsky, L. S. (1978*). Mind in society: The development of higher psychological processes.* Cambridge: MA, Harvard University Press.

Popooola, A. A. (2002). *Effects of heuristic problem-solving and programmed instructional strategies on senior secondary school students' learning outcomes in mathematics in Ekiti State,* Nigeria. Unpublished PhD Thesis, University of Ibadan.

Posner, G. J., Strike, K. A., Hewson, P. W., & Gertzog, W. A. (1982). Accommodation of a scientific conception: towards a theory of conceptual change. *Science Education, 66* (2), 211 – 227.

Qualters, D. (2001). Do students want to be active? *The Journal of Scholarship of Teaching and Learning, 2* (1), 51-60.

Rammayah, M., Siyanandan, P., Nasrijal. N. H., Letchumanan. T., & Leong. L. C. (2009). Preferred learning style: Gender influence on preferred learning style among Business students. *Journal of US-China Public Administration, 6* (4), 64-72.

Reid, J. M. (1995). *Learning styles in the ESL/EFL classroom.* Boston: Heinle & Heinle Publishers.

Romer, D. (1993). Do students go to class? Should they? *Journal of Economic Perspectives, 7(3),* 167– 174.

Rosemond, D. G. (2006). Acquisition of scientific attitudes and its relevance to science educators. *A paper presented at the median seminar of Faculty of Sciences,* Nigeria.

Rosini, B. A., & Jim, F. (1997). The effect of cooperative learning methods on achievement, retention, and attitudes of home economics students in North Carolina. *Journal of Vocational and Technical Education. 13* (2), 1-7.

Samuel, W. W., & John, G. M. (2004). Effects of cooperative class experiment teaching method on secondary school students' chemistry achievement in Kenya's Nakuru District. *International Education Journal, 5* (1), 26-35.

Schunk, D. H. (1996). *Learning theories: an educational perspective* (2nd ed.). Englewood Cleffs N. J. Messill.

Semb, G. B., & Ellis, J. A. (1994). Knowledge taught in school: What is remembered? *Review of Educational Research*, *64*, 253-286.

Semb, G. B., Ellis, J. A., & Aranjo, J. (1993). Long-term retention of knowledge learned in school. *Journal of Educational Psychology*, *85*, 305-316.

Semb, G. B., Ellis, J. A., & Montague, W. E. (1990*). Long-term memory for knowledge taught in school.* Navy Personnel Research and Development Center. San Diego.

Seymour, E., & Hewitt, N. (1997). *Talking about leaving: why undergraduates leave the sciences*. Boulder, Colorado: West View Press.

Sheppard, K,. & Robbins, D. M. (2002). Lessons from the committee of ten. *Physics Teacher*, *40*, 426- 432.

Siegfried, J., & Fels, R. (1979). Research on teaching college economics: A Survey. *Journal of Economic Literature*, *17(*3*)*, 923 – 939.

Slavin, R. E. (1986). Team-Assisted Individualization: Combining cooperative learning and individualized instruction in mathematics. In R. E. Slavin, S. Sharan, S. Kagan, R. Hertz- Lazarowitz, C. Webb, & R. Schmuck (Eds.), *Learning to cooperative, cooperating to learn* (pp. 177–209). New York: Plenum.

Slavin, R. E. (1990). *Cooperative learning: theory, research, and practice*. New Jersey: Prentice Hall.

Slee, F. W. (1964). *A factorial study of the study attributes of secondary modern children to school subjects,* Unpublished M.Ed. Thesis, Manchester University

Smith, M. K. (1997). John Dewey and the process of education. *The encyclopedia of informal education*. Retrieved 8 March 2013.

Smith, M. E., Hinckley, C. C., & Volk, G. L. (1991). Cooperative learning in the undergraduate laboratory. *Journal of Chemical Education, 68* (5), 413- 415.

Soyibo, K. (1985). A comparison of selected Lagos students' attitudes to and performance on a biology test. In F. Obannya and O. Dubanmi (eds). *Education in Lagos State. An overview*: *selected papers from a conference on education development in Lagos State* held at Lagos State University.335-351.

Spelke, E. S. (2005). Sex differences in intrinsic aptitude for mathematics and science: A critical review. *American Psychologist 60* (9), 950-958.

Springer, L., Stanne, M. E., & Donovan, S. (1997). *Effects of small-group learning on undergraduates in science, mathematics, engineering, and technology: A meta-analysis Review of Educational Research, 69*(9*),* 21-51.

Ssempala, F. (2005*). Gender differences in performance of chemistry practical skills among senior six students in Kampala District*, PhD thesis. Boca Raton, University of Florida.

Steinbrink, J. E., Walkiewicz, S. K., & Stahl, R. J. (1995). Jigsaw III = jigsaw II + cooperative test review: Applications to the language arts classroom. In R. Stahl (Ed.), *Cooperative learning in language arts: A handbook for teachers* (pp. 159-179). Menlo Park, CA: Addison-Wesley.

Stofflett, R. T. (1998). Putting constructivist teaching into practice in undergraduate introductory science. *Electronic Journal of Science Education, 3* (2), 210-253.

Tamir, P. (1982). The relationship among cognitive preference school environment teachers curricula bias, curriculum and subject matter. *American Education Research Journal, 12 (3),* 235 – 64.

Thurstone, L. L (1929). Experimental and Mathematical Psychologist". *The American Psychologist 23* (11). 786–802. doi:10.1037/h0026696. PMID 4881041.

Tobin, K., & Fraser, B. J. (1988). Investigations of exemplary practice in high school science and mathematics. *Australian Journal of Education, 32* (1), 75-94.

Towns, M. H., & Kreke, K. (2000). An action research project: student perspectives on small-group learning in chemistry. *Journal of Chemical Education, 77,* 111–115.

Tyler, R., Waldrip, B., & Griffiths, M. (2004). Windows into practice: Constructing effective science teaching and learning in a school change initiative. *International Journal of Science Education, 26* (2), 171-194.

Tyson, L., & Treagust, D. F. (1999). The complexity of teaching and learning chemical equilibrium .*Journal of Chemical Education, 76,* 554-558.

Udousoro, U. J. (2000). *The relative effects of computer and text-assisted programmed instruction on students' learning outcomes in mathematics.* Unpublished Ph.D Thesis, University of Ibadan.

Ulrich, D., & Glendon, K. (1995). Jigsaw: A critical-thinking experience. *Nurse Educator, 20* (3), 6-7.

Virginia Association of Science Teachers [VAST], (1998). *What is constructivism and what does it mean for science educators?* Current topics in science education retrieved January 2, 2012 from http://www.pen.k12.va.us/Anthology/Pav/Va_Assoc_Sci/construct2.html.

Vygotsky, L. (1978). Interaction between learning and development. In Gauvain & Cole (Eds.), *readings on the development of children (pp.34-40).* New York: Scientific American Book

Wall, M. S (1997). Occupational Self-Selection: A Human Capital Approach to Sex Differences in Occupational Structure, Review *of Economics and Statistics, 63,* 60- 69.

West Africa Examination Council. (2002). *Senior Secondary School Certificate Examination, Chief Examiners' Report.* Accra: West African Examination Council.

West Africa Examination Council. (2007). *Senior Secondary School Certificate Examination, Chief Examiners' Report.* Accra: West African Examination Council.

West Africa Examination Council. (2009). *Senior Secondary School Certificate Examination, May/June (2009). Chief Examiners' Report.* Accra: West African Examination Council.

Weinburgh, M. (1995). Sex differences in students' attitudes toward science: A meta-analysis of the literature from 1970 to 1991. *Journal of Research in Science Teaching, 32,* 387-393.

Wilson, S. (1998). The effect of two teaching styles on children's skill performance and task analyses ability related to skill observation. *Research Quarterly for Exercise and Sport; Abstract of Completed Research.*

Wilson, V. L. (1983). A metal-analysis of the relationship between science and achievement and science attitude: kindergarten through college. *Journal of Research in Science Teaching*, *20* (9), 839-885.

Wilson, B., & Cole, P. (1991). A review of cognitive teaching models. *Educational Technology Research and Development*, 39 (4), 47–64.

Woods, D. R. (1995). Teaching and learning: what can research tell us? *College Science Teaching, 25*, 229-232.

Wood, E. E. (1994). *The S.S.S elective chemistry: perceptions of students and teachers in the Cape Coast Municipality*. Unpublished PGDE dissertation. Cape Coast: University of Cape Coast.

Wood, W. B., & Gentile, J. M. (2003). Teaching in a research context. *Journal of Science education, 302*, 1510.

Wu, H. K., Krajcik, J. S., & Soloway, E. (2001). Promoting understanding of chemical representations: students' use of a visualization tool in the classroom. *Journal of Research in Science Teaching*, *38* (7), 821–842.

Yager, R. E., Hadyat, E. M., & Penick, J. (1988). Features which separate least effective from most effective science teachers. *Journal of Research in Science Teaching,25* (3), 165-177

Yingjie, L., & Zaiqun, L. (2003). Using appropriate strategies to improve teaching and learning in organic chemistry and organic chemical experiment courses. *The China Papers, 2,* 34-38.

Yore, L. D. (2001).What is meant by constructivist science teaching and will the science education community stay the course for meaningful reform? *Electronic Journal* *of Science Education,* 5(4), 123-345. Retrieved from http://unr.edu/homepage/crowther/ejse/yore.html.

Zhu, Z. (2007). Gender differences in mathematical problem solving patterns: A review of literature. *International Education Journal*, *8* (2), 187-203.

Zoller, U. (1990). Students' misunderstandings and alternative conceptions in college freshman chemistry (general and organic), *Journal of Research in Science Teaching, 27* (10), 1053–1065.

Zull, J. (2002). *The art of changing the brain: Enriching the practice of teaching by exploring the biology of learning.* Sterling, VA: Stylus Publishing, L.L.C..

APPENDIX A

OCCT (PRE-TEST)

ORGANIC CHEMISTRY CONCEPT TEST (OCCT)

UNIVERSITY OF EDUCATION, WINNEBA

DEPARTMENT OF SCIENCE EDUCATION

This questionnaire aims to find out your basic knowledge about organic chemistry. Please respond to each item to the best of your knowledge. Your thoughtful and truthful responses will be greatly appreciated. Your responses will be kept confidential and will not affect your examination result anywhere; it will be used only for research purposes. Thank you for taking time to complete this questionnaire.

Please read the following statements and kindly provide the information.

School……………………………………………………………………………..………..

Name…………………………………………………………………………………..…….

Sex……………………………………………………………………………………..……….

Time: 40 minutes

SECTION A [Multiple-Choice Objective Test]

Instruction: *Each question in this section is followed by four options lettered 'A' to 'D'. Choose the most appropriate option for your answer by circling around the letter that corresponds to your chosen option with a pencil.* ***If you decide to change your answer, erase the first one completely and re-circle your new choice***

1. The general molecular formula for alkynes is

A. CnH_3n+2 B. CnH_2n-2 C. CnH_2n-1 D. CnH_2n

2. How many hydrogen atoms are contained in an alkane with four carbon atoms?

A. 4 B. 6 C. 8 D. 10

3. The products of the fermentation of sugar are ethanol and

A. water

B. oxygen

C. carbon dioxide

D. sulfur dioxide

4. The hydrocarbon normally used by welders is

A. Benzene B. Ethyne C .Methane D. Propyne

5. The IUPAC name for the compound $CH_3CH(CH_3)\,CHClCH(CH_3)\,CH_2CH_3$

A. 2, 4-dimethyl-3-chlorohexane B. 3-5-dimethyl-4-chlorohexane

C. 4-chloro-3, 5-dimethylhexane D. 3-chloro-2, 4-dimethylhexane

6. When alkanoic acids are heated with alkanols, the major product formed is

A. Alkane B. Alkene C. Amide D. Alkyl alkanoates

7. The compound with the formula CH_3CONH_2 is an

A. Alkanoate B. Alkanols C. Amide D. Amine

8. Which of the following pairs of compounds belongs to the same homologous series?

A. CH_4 and C_2H_6 B. C_2H_4 and C_2H_2 C.CH_4 and C_2H_4 D. C_2H_6 and C_3H_6

9. Ethene can be produced from paraffin oil by the process known as

A. Polymerization B. Cracking C. Vulcanization D. Hydrogenation

10. A compound which has molecular formula C_2H_6O, could be an

A. Alkanol B. Alkanoic acid C. Alkanoate D. Amide

11. When oranges are rotten, they taste sour. The family of compounds responsible for the sour taste is………..

A. Esters B. Alkenes C. Alkanols D. Alkanoic acids

12. The organic compound present in vinegar is an

A. Alkane B. Alkanoates C. Alkanol D. Alkanoic acids

13. A pleasant fruity scent produced when an Alkanol is warmed with a compound A in the presence of concentrated tetraoxosulphate (VI) acid. A could be

A. An alkene B. An alkanoate C.An alkanoic acid D. A phenol

14. The reaction $CH_3COOC_2H_5 + NaOH \rightarrow CH_3COONa + C_2H_5OH$ is an example of

A. Saponification B. Esterification C. A condensation process

D. Neutralization

15. The name of the compound with the formula $CH_3COOCH_2CH_2CH_3$ is

A. Pentanoic acid B. Pentanol C. Propylethanoate

D. Ethyl propanoate

16. Which of the following hydrocarbons will not decolorize bromine water?

A. Ethane B. Ethane C. Ethyne D. Propene

17. What is the best method of separating a mixture of petrol and kerosene?

A. Use of separating funnels B. Simple distillation

C. fractional distillation D. Chromatography

18. Which of the following compounds is not a product of the reaction between chlorine and methane?

A.CH_3Cl B. CH_3Cl_2 C. C_2H_5Cl D. $CHCl_3$

19, Cracking of petroleum is an important industrial process because it

A. increase the length of carbon chain in the petroleum

B. reduces knocking and smoothing combustion

C. increases the quality of petrol

D. decreases the octane number

20. What is the molecular formula of 2, 2, 3-trimethylpentane?

A. $(CH_3)_3CCH_2CH_2CH_3$ B. $CH_3C\ (CH_3)_2CH_2CH\ (CH_3)\ CH_3$

C. $(CH_3)_2CHCH\ (CH_3)\ CH_2CH_3$ D. $CH_3C\ (CH_3)_2CH\ (CH_3)\ CH_2CH_3$

21. Which element is present in all organic compounds?

A. Carbon B. Nitrogen C. Oxygen D. Phosphorous

22. Which property is generally characteristic of an organic compound?

A. Low melting point B. High melting point

C. Soluble in polar solvents D. Insoluble in nonpolar solvents

23. Compared to the rate of inorganic reactions, the rate of organic reactions generally is

A. slower because organic particles are ions

B. slower because organic particles contain covalent bonds

C. faster because organic particles are ions

D. faster because organic particles contain covalent bonds

24. Which of the following compounds are isomers?

A. 1-propanol and 2-propanol B. Methanoic acid and ethanoic acid

C. Methanol and methanal D. Ethane and ethanol

25. Which statement explains why the element carbon forms so many compounds?

A. Carbon atoms combine readily with oxygen.

B. Carbon atoms have very high electronegativity.

C. Carbon readily forms ionic bonds with other carbon atoms.

D. Carbon readily forms covalent bonds with other carbon atoms.

26. Which polymers occur naturally?

A. Starch and nylon   B. Starch and cellulose

C. Protein and nylon   D. Protein and plastic

27. What is the name of the compound that has the molecular formula C_6H_6?

A. hexane   B. hexene   C. Benzene   D. hexatone

28. In a molecule of CH_4, the hydrogen atoms are spatially oriented toward the centers of a regular

A. Pyramid   B. Tetrahedron   C. Square   D. Rectangle

29. In which pair of hydrocarbons does each compound contain only one double bond per molecule?

A. C_2H_2 and C_2H_6 B. C_2H_2 and C_3H_6 C. C_4H_8 and C_2H_4

D. C_6H_6 andC_7H_8

30. The reaction $CH_2CH_2 + H_2$ -> CH_3CH_3 is an example of

A. Substitution   B. Addition   C. Esterification   D. Fermentation

31. Which of the following compound is a saturated hydrocarbon?

A. Ethane   B. Ethene   C. Ethyne   D. Ethanol

32. What is the maximum number of covalent bonds than an atom of carbon can form?

A. 1   B. 2   C. 3   D. 4

33.Which class of organic compounds can be represented as R -- OH?

A. Acids B. Alcohols C. Esters D. Ethers

34. Which molecule contains a total of three carbon atoms?

A. 2-methylpropane B. 2-methylbutane C. Propane D. Butane

35.What substance is made up of monomers joined together in long chains?

A. Ketone B. Protein C. Ester D. Acid

36.Which compound is an organic acid?

A. CH_3OH B. CH_3OCH_3 C. CH_3COOH D. CH_3COOCH_3

SECTION 'B' [True/False]

Instructions: *Read each given statement carefully and indicate whether it is true or false by underlining your choice of the two options given*

37. Arenes are aromatic hydrocarbons. True/ False

38. All the organic compounds are generally insoluble in polar solvent. True/ False

39. $CH_3CH_2CH_2CH_2CH_2CH_2CH_3$ is known as heptanes. True/ false

40. Propanoic acid has the molecular formula $CH_3CH_2CH_2COOH$. True/False

APPENDIX B

POST TEST/DELAYED POST TEST

(SKOCCT& SRATOC)

UNIVERSITY OF EDUCATION, WINNEBA

DEPARTMENT OF SCIENCE EDUCATION

Dear Students,

This test is aimed at assessing your fundamental knowledge in chemistry. This is to enable your teacher adopt the most appropriate teaching approach to help you get the best tuition in chemistry in subsequent days. Results of this test will be treated confidentially.

Thank you.

Name of Student: ………………………………………………………………………………

Sex ………………………………………………………………………………………….

School: …………………………………………………………………………………….

TIME: 40 minutes

SECTION A [Multiple-Choice Objective Test]

Instruction: *Each question in this section is followed by four options lettered 'A' to 'D'. Choose the most appropriate option for your answer by circling around the letter that corresponds to your chosen option with a pencil.* ***If you decide to change your answer, erase the first one completely and re-circle your new choice.***

1. How many hydrogen atoms are contained in an alkene with four carbon atoms?

A. 4 B. 6 C. 8 D. 10

2. The compound with the formula CH_3CONH_2 is an

A. Alkanoate B. Alkanols C. Amide D. Amine

3. Benzene normally undergoes

A. A condensation reaction　　B. An oxidation reaction

C. A reduction reaction　　D. A substitution reaction

4. To which of the following groups does benzene belong?

A. Aromatic　B. Alicyclic　C. Aliphatic　D. heterocyclic

5. The name of the compound with the formula$CH_3COOCH_2CH_2CH_3$ is

A. Pentanoic acid　B. Pentanol　C. Propylethanoate　D. Ethyl propanoate

6. The general molecular formula of alkene is

A. C_nH_{2n-2}　B. C_nH_{2n+2}　C. CnH_{2n}　D. C_nH_{2n+1}

7. A compound which has molecular formula C_2H_6O, could be an

A. Alkanol　B .Alkanoic acid　C. Alkanoate　D. Amide

8. Which of the following pairs of compounds belongs to the same homologous series?

A. CH_4 and C_2H_6　B.C_2H_4 and C_2H_2

C. CH_4 and C_2H_4　D. C_2H_6 and C_3H6

9. The IUPAC name for the compound $CH_3CH(CH_3)CHClCH(CH_3)CH_2CH_3$

A. 2,4-dimethyl-3-chlorohexane　B. 3-5-dimethyl-4-chlorohexane

C. 4-chloro-3, 5-dimethylhexane　D. 3-chloro-2, 4-dimethylhexane

10. What is the systematic name of the compound below?

$CH_3CH(Cl)CH(CH_3)\ CH_2CH_3$

A. 2-chloro3-methylpentane　B. 5-chloro-3-methylpentane

C. 3-methyl-3-chloropentane　D. 5-methyl-3-chloropentane

11. What is the name of the compound that has the molecular formula C_6H_6?

A. Butane　B. Butene　C. Benzene　D. Butyne

12. The following are all alkyl substituent except

A. Hexyl B pentyl C. cyano D. ethyl

13.In which pair of hydrocarbons does each compound contain only one double bond per molecule?

A. C_2H_2 and C_2H_6 B. C_2H_2 and C_3H_6 C. C_4H_8 and C_2H_4

D. C_6H_6 andC_7H_8

14.The reaction $CH_2CH_2 + H_2 \rightarrow CH_3CH_3$ is an example of

A. Substitution B. Addition C. Esterification D. Fermentation

15.Which compound is a saturated hydrocarbon?

A. Ethane B. Ethene C. Ethyne D. Ethanol

16. What is the maximum number of covalent bonds that an atom of carbon can form?

A. 1 B. 2 C. 3 D. 4

17.Which class of organic compounds can be represented as R -- OH?

A. Acids B. Alcohols C. Esters D. Ethers

18. Which molecule contains a total of three carbon atoms?

A. 2-methylpropane B. 2-methylbutane C. propane D. butane

19What substance is made up of monomers joined together in long chains?

A. Ketone B. Protein C. Ester D. Acid

20.During fractional distillation, hydrocarbons are separated according to their

A. Boiling points B. Melting points C. Triple points

D. Saturation point

21. Which compound is an organic acid?

A. CH_3OCH_3 CH_3OH B.CH3OCH_3 C. CH_3COOH D. CH_3COOCH_3

22. Which element is present in all organic compounds?

A. Carbon B. Nitrogen C. Oxygen D. Phosphorous

23. Which property is generally characteristic of an organic compound?

A. Low melting point B. High melting point

C. Soluble in polar solvents D. Insoluble in nonpolar solvents

24.Compared to the rate of inorganic reactions, the rate of organic reactions generally is

A. Slower because organic particles are ions

B. Slower because organic particles contain covalent bonds

C. Faster because organic particles are ions

D. Faster because organic particles contain covalent bonds

25.Which following of compounds are isomers?

A. 1-propanol and 2-propanol B. Methanoic acid and ethanoic acid

C. Methanol and methanal D. Ethane and ethanol

26.Which statement explains why the element carbon forms so many compounds?

A. Carbon atoms combine readily with oxygen.

B. Carbon atoms have very high electronegativity.

C. Carbon readily forms ionic bonds with other carbon atoms.

D. Carbon readily forms covalent bonds with other carbon atoms.

27. Which polymers occur naturally?

A. Starch and nylon B. Starch and cellulose

C. Protein and nylon D. Protein and plastic

SECTION 'B' [Fill in the Blank]

Instruction: *In the blank space provided in each of the given sentences, write one most befitting word that will make the resulting sentence valid.*

28. The carboxylic acids are also called...

29. The functional group of carboxylic is...

30. Methanoic acid is commonly called...

31..................................is the general molecular formula of alcohol

32. ....is the formula for the substituent-hydroxyl

33.................................. is the general name for the substituent $-CH_3$

SECTION 'C' [True/False]

Instructions: *Read each given statement carefully and indicate whether it is true or false by underlining your choice of the two options given*

34. Butanoic acid is found butter. True/ False

35. Alcohols are classified into primary, secondary and tertiary according to the number of OH group present. True /False

36. Arenes are aromatic hydrocarbons. True/ False

37. All the organic compounds are generally insoluble in polar solvent. True/ False

38. $CH_3CH_2CH_2CH_2CH_2CH_2CH_3$ is known as heptanes. True/ false

39. $C_{11}H_{23}OH$ is known as decanol. True/ False

40. Propanoic acid has the molecular formula $CH_3CH_2CH_2COOH$. True/False

APPENDIX C

CHEMISTRY STUDENTS' PERCEPTION AND ATTITUDE TOWARDS ORGANIC CHEMISTRY (CSPATOC)

UNIVERSITY OF EDUCATION, WINNEBA
DEPARTMENT OF SCIENCE EDUCATION

This questionnaire aims to find out the perceptions and attitudes of students towards organic chemistry. Please respond to each item to the best of your knowledge. Your thoughtful and truthful responses will be greatly appreciated. Your responses will be kept confidential and will not affect your examination result anywhere; it will be used only for research purposes. Thank you for taking time to complete this questionnaire.

Name of Student: …………………………………………………………………………….

Sex ………………………………………………………………………………………..

School……………………………………………………………………………………..

Instruction: *Each question in this section is followed by four options. Choose the most appropriate option for your answer by ticking (√) the box that corresponds to your chosen option with a pencil.* ***If you decide to change your answer, erase the first one completely and re-tick your new choice***

Item/ Options	Strongly Agree (SA)	Agree(A)	Disagree (DA)	Strongly Disagree (SD)
1. Chemistry is difficult especially organic chemistry				
2. Organic chemistry is very interesting				
3. Organic compounds structures are more terrifying				
4. Naming of hydrocarbons is confusing				
5. The food aspects in organic chemistry make it practical.				
6. The organic chemistry textbook is not helpful.				
7. Organic chemistry is not usable in daily life situations, and is not important to learn.				
8. I participate in chemistry discussions often, and it is enjoyable.				
9. Chemistry knowledge is necessary in my future career.				
10. I have enjoyed studying organic chemistry.				
11. Organic chemistry lessons are very boring.				
12. I am always under a terrible stress in chemistry class.				
13. Organic chemistry concepts and its structures are unfamiliar to me				
14. Organic chemistry makes me restless, irritable, and impatient				
15. I have good feelings toward chemistry in general				
16. I am comfortable with chemistry and it is not difficult very much				
17. Organic chemistry knowledge is necessary in my future career.				
18. It makes me nervous to think about problem solving in organic chemistry.				
19. I don’t like organic chemistry and I am afraid to learn it.				
20. I like chemistry because of the teacher				

APPENDIX D

SAMPLE EXPERT SHEET FOR THE HOME AND EXPERT GROUPS

Expert sheet for naming of alkene

1. What is the general molecular formula for alkene?

2. State the functional group of alkene.

3. What is the common name of alkenes?

4. Write the structural formula for 2-methylbut-2-ene and trans-3, 4-dihydroxyhex-3-ene

5. Name the following compounds.

(i) $H_2C{=}CH_2$ (ii) $CH_3\text{-}CH{=}CH_2$ (iii) $CH_3C\ (CH_3)_2CH\ {=}CH_3$

(iv) $H_2C{=}C(Br)\text{-}CH{=}CH_2$

Expert sheet for naming alkynes and benzene

1. Outline the steps to follow when naming alkynes and benzenes.
2. What is the general molecular formula of alkyne?
3. State the functional group of alkyne.
4. Draw the structures of the following compounds
   (i) 1,4-dinitrobut-2-yne (ii) 2,2,3,3-tetramethylnon-4-yne (iii) chlorobenzene
   (iv) 4-methyl-1-pentyne (v) 1-methyl-2,6-dinitrobenzene

Expert sheet for naming alkanols

1. What is the name and the formula of the functional group of alkanols?
2. Write the general molecular formula of alkanols.
3. Outline the steps for the nomenclature of alkanols.
4. Draw the structures of the following compounds
   (i) 1,1-dichloro-2-methylpropan-1-ol
   (ii) 2-methylcyclopentanol
   (iii) Ethanol
   (iv) 5-Bromo-3-ethylheptan-3-ol

Expert sheet for the nomenclature of Alkanoic acids (Carboxylic acids)

1. State the molecular formula and the functional group of alkanoic acids.
2. Outline the steps of naming alkanoic acids
3. What are the names giving to compounds when the functional group of alkanoic acids is attached to aliphatic and aromatic compounds respectively?
4. Name the following compounds.
   (i) $(COOH)_2$
   (ii) $HOOC\text{-}CH_2\text{-}CH_2\text{-}COOH$
   (iii) $H_2C(Br)COOH$
5. Write the structure of the following organic compounds.
   (i) Methanoic acid
   (ii) 2-chlorobutanic acid
   (iii) Benzoic acid or phenyl methanoic acid
   (iv) 5-bromo-2-methyl-3-heptanoic acid

Expert sheet for naming alkyl Alkanoates (esters)

1. Explain the functional group of esters.
2. Outline the steps of naming of Alkanoates
3. Draw the structures of the following compounds.
   (i) Methyl-2-hydroxyethanoate
   (ii) Methyl ethanoate
   (iii) Ethyl-2,3-dichloropropanoate
   (iv) phenyl methanoate
4. Name the following organic compounds
   (i) $CH_3CH_2CH(CH_3)CH_2COOC_3H_7$
   (ii) $CH_3(CH_3)COOC_6H_5$
   (iii)$HCOOCH_3$

APPENDIX E

RELIABILITY CO-EFFICIENTS OF RESEARCH INSTRUMENTS

(CRONBACH'S ALPHA) FROM SPSS

1. **Pre-test (OCCT)**

Case Processing Summary

		N	%
Cases	Valid	40	100.0
	Excluded[a]	0	.0
	Total	40	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.721	40

2. **Post-test / Delayed post test (SKOCCT/ SRATOC)**

Case Processing Summary

		N	%
Cases	Valid	40	100.0
	Excluded[a]	0	.0
	Total	40	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.781	34

3. **Perception and Attitude Questionnaire (CSPATOC}**

Case Processing Summary

		N	%
Cases	Valid	20	100.0
	Excluded[a]	0	.0
	Total	20	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.789	20

APPENDIX F

LETTER OF INTRODUCTION

UNIVERSITY OF EDUCATION, WINNEBA
DEPARTMENT OF SCIENCE EDUCATION
P. O. BOX 25, WINNEBA - TEL. NO. 0202041079

Our Ref. No.
Your Ref. No.

8th March, 2013

TO WHOM IT MAY CONCERN

Dear Sir/Madam

INTRODUCTORY LETTER

The bearer of this letter **Mr. Solomon Sarkodie** is a student, reading Master of Philosophy in Science Education, in the University of Education, Winneba. He is investigating into "Using jigsaw cooperative model to enhance S.H.S chemistry students' performance in classification and nomenclature of organic compounds''.

I will appreciate it if you could kindly assist him with his investigation.

I count on your co-operation for a successful thesis write-up.

Thank you.

Yours faithfully,

Dr. I. K. Anderson
Head of Department