

CHAPTER ONE

INTRODUCTION

Background to the Problem

Science is an organized body of knowledge that deals with the investigation of natural phenomenon. It is a methodical and analytical approach to discovering how various entities in the universe work. It is also the body of knowledge accumulated through discoveries about living and non-living things in the universe (Bradford, 2015). It is defined as a body of knowledge, a way or method of making inquiry and reasoning in the pursuit of an understanding nature (Abimbola, 2013). Science can also be described as the bedrock for the technological development of any nation. It is a crucial tool for national growth as well as an integral part of the society and consequently, individuals' knowledge of science in national development cannot be overemphasized.

Science at the secondary school level in Nigeria, consists of three major branches: physics, chemistry, and biology. Chemistry is a branch of science that deals with the study of the nature, properties, and changes that matter undergo. As a physical science, it focuses on the study of the properties and interaction between energy and matter. It is defined as a sub-discipline of science that studies the constituents, properties, and uses of matter (Ababio, 2013; Friedl, 2016).

Chemistry is a discipline in science that is sub divided into five main branches which are analytical, physical, organic, inorganic and environmental chemistry. Organic chemistry refers to that branch of chemistry which addresses the study of compounds containing molecules of carbon and hydrogen, and could contain other elements. It is a sub-discipline in chemistry which entails the scientific investigation of the structure, properties, and reactions of organic compounds and

organic materials, i.e., matter in its diverse forms that contain carbon and hydrogen atoms with other elements (Clayden, Greeves & Warren, 2012). Organic chemistry is a prerequisite to understanding the application of chemistry in other areas such as: polymer chemistry, pharmaceutical chemistry and biochemistry (Akpokiere, 2015).

In the senior secondary school chemistry curriculum, organic chemistry is contained in the fourth theme, ‘the chemistry of life’. This theme includes carbon and its compounds, hydrocarbons, and alkanols, fats and oils, soap and detergents and giant molecules. Hydrocarbons refers to compounds containing carbon and hydrogen only. They can be straight-chain, branched chain, or cyclic molecules that emerged as a result of the capability of carbon to catenate. There are two classes of hydrocarbons: aliphatic (alkanes, alkenes, alkynes) and aromatic (benzene). The study of hydrocarbons is prerequisites to understanding other aspects of organic chemistry.

Despite the importance of chemistry, its teaching and learning have been confronted with various challenges, a major one of which is the teacher-related factor. The teacher-related factor deals with the form of teachers’ presentation of instruction to learners (Omorogbe & Ewansiha, 2013). It has been argued that Chemistry lessons are presented in dogmatic styles which to a large extent inhibit meaningful learning. Such styles make students resort to rote memorization of scientific facts and concepts. There is thus an imperative need for chemistry teachers to be exposed to and equipped with relevant skills for other instructional strategies that may probably improve their effectiveness and consequently assist them to excel in the teaching of chemistry.

Instructional strategies are specific instructional activities a teacher utilizes to deliver the contents of instruction which in turn influences students’ learning. They can be referred to as techniques that organize contents of instruction in a specific manner for remembering, motivating

and helping students to focus attention during lessons. They transform to learning strategies when students select and use them independently to achieve instructional objectives (Alberta, 2002).

The choice of a teaching strategy adopted by a teacher largely depends on the nature of information or skill that is to be taught. This is applicable in the teaching and learning of chemistry, where effective teaching strategies can help students to become active participants in learning, initiate or develop critical thinking skills, and keep them on task. One of the instructional strategies that has gained the attention of science education researchers is the use of advance organizer. This is an instructional unit that focuses on what is important and essential in a lesson. It is prepared at a higher level of abstraction, generality, and inclusiveness when compared with the content to be presented. It is used to promote learning and retention of new information (Woolfolk, 2001). Advance organizer is usually introduced prior to direct instruction for the purpose of bridging the gap between what learners are already familiar with and what they need to understand in a new lesson. They are presented in formats of text, graphics, or hypermedia (Ausubel, 1968).

Advance Organizers are organizational cues and tools that are used to link what learners are familiar with to the unfamiliar or unknown. They are frameworks for assisting students to comprehend or assimilate what they will be learning in a new lesson by providing hints in form of order, sequence, and relationships. Some examples of advance organizer include: anticipatory set, behavioural objectives, agenda items, textbook headings, questions, and graphic organizer among others. An advance organizer is thus a statement of inclusive concepts to introduce and sum up material that follows. Besides, it is information that is introduced in antecedent to learning to be used by the learner to organize and elucidate new learning material (Mayer, 2003). The advance organizer exists in various forms: expository, narrative, skimming and graphic organizers. Expository advance organizer presents new knowledge in form of description, while narrative

advance organizer presents new information in details which is usually in a story format. Skimming requires quickly reading over through information to identify the main ideas, while graphic organizers make use of the spatial arrangements of concepts to be learnt (Hendron, 2003).

Graphic Organizers are spatial representation of texts. They are pedagogical tools that can avail students with the opportunity to systematically layout and structure information or concepts to establish relationships between them and other concepts (Zaini, Mokhtar & Nawawi, 2010). In the teaching and learning of chemistry, the spatial arrangement of concepts is extremely important since it allows chemistry students to identify the missing information or absent connections in their strategic thinking (Ellis, 2004). Hence, graphic organizers as tools that allows for spatial arrangement of concepts was investigated in this study. Besides, graphic organizers are used to illustrate students' prior knowledge about a topic or section of a text that have been recommended to be used in classrooms. They are therefore, visual display, or templates that portrays the connections or relationships among the major concepts involved in a lesson, unit, or learning task (Braselton & Decker, 1994). In chemistry teaching for instance, graphic organizers are easy to adopt tools that allow chemistry teachers to probe into their students' thinking and learning on a specific topic of study (Struble, 2007).

There are six patterns of graphic organizers: hierarchical, conceptual, sequential, evaluative, relational and cyclical (Gill-Garcia & Villegas, 2003). When making a choice of a graphic organizer, it is important to determine the complexity of the text to be presented, the organizer should fit the curriculum content and the structural pattern of the text should also agree with the organizer selected. The hierarchical pattern of graphic organizer requires breaking down content of instruction to identify the concept and sub-concepts or levels. These sub-concepts or levels are ranked by relevance or importance and arranged from top to bottom or vice-versa

depending on their relationship to the main concept. Hierarchical graphic organizers include the Arch Diagram, Branching Diagram, Classifying Chart, and Topic/Subtopic Web.

The sequential graphic organizer presents learning materials in form of a sequence of events in an orderly and timely manner. Examples of sequential graphic organizers include; Cause/Effect, Problem/Solution, T-Chart, Story Board, and Sequencing Chart. Cyclical graphic organizers present information about natural cycles by showing relationships between concepts in a cyclical pattern. Specifically, they are used to evaluate students' understanding of natural cycles. Cyclical graphic organizers include the Circle Organizer and Circle Diagram. The conceptual graphic organizers expresses knowledge by providing relationships between key concepts present in the learning material. They are used to appraise students' understanding of a concept or a central idea of a topic. In this type of graphic organizer, students provide supporting evidences inform of proofs such as facts, characteristics, or descriptions of the key concept. Some examples of conceptual graphic organizers are applicable to learning chemistry and other science subjects are: Concept Map and Mind Map (Struble, 2007). The various patterns of graphic organizers are presented in Table 1.

Table 1*Patterns of Graphic Organizer and the Organizational Pattern of Text*

Patterns of Graphic Organizer	Organizational Pattern of Text
Hierarchical	Categories and subcategories, matrix, plot, tree, pyramid
Conceptual	Description, collection, mind map, word web, comparison/contrast, concept map,, KWL
Sequential	Time line, cause/ effect, chronology, process/ product, problem/ solution, cycle graph, line graphs.
Evaluative	Agreement scales, satisfaction scales, evaluation charts (PMI chart)
Relational	Cause/ effect, fishbone, target, pie chart, characteristic chart
Cyclical	Cycle graph, life cycle, repetitive events

Source: Gil-Garcia and Villegas (2003)

In the present study, the effect of the use of graphic organizer on students' achievement in chemistry is being investigated due to the fact that graphic organizer puts the content of instruction in a precise form that helps students to differentiate between what is important to know and what is interesting in the learning material. Graphic organizer generally reduces information processing by the learner thereby reducing cognitive processing of the mind. This is feasible because the content of instruction is presented at more sophisticated and complex levels in contrast with other forms of advance organizers. Graphic organizer's advantage of the spatial representation of learning material facilitates understanding of new chemistry concepts among students especially those with learning disabilities. Students' ability to construct and use graphic organizers has been found to improve their learning skills which could help them become strategic learners (Masterminds, 2001). Concept map and mind map are two examples of conceptual pattern of graphic organizer used to assess conceptual understanding of learners about a central idea of

subject matter content. In the present study, it is hydrocarbons. The similarity between the two maps and inconsistencies in scholars' opinion in choosing either of the two mapping strategies that is best for teaching and learning of chemistry were considered (Duffill, 2013; Frey, 2016; Struble, 2007).

Concept mapping is premised on Ausubel's assimilation theory of cognitive learning (Ausubel, Novak & Hanesian, 1978). Concept maps are two-dimensional graphical representations of an individual's knowledge of a domain (Novak & Gowin, 1984). The basic assumption of the theory is that meaningful learning take place when new knowledge is consciously and deliberately linked to an extant framework of prior knowledge. Mind maps are graphic organizers that utilize non- sequential approaches to learning and they require the learner to think and explore concepts in the learning material. In a mind map, the key concept is placed at the center of the map as opposed to being at the top as in the case of concept maps. While concept maps are specifically designed for representing knowledge which visualizes and communicates knowledge, mind maps present instruction in a more flexible and personal way but are more visually structured when compared with the concept maps. Therefore, the present study determined the effectiveness of each of these mapping strategies. Table 2 presents the comparison of concept maps and mind maps organizers.

Table 2*Comparison of Concept maps and Mind Maps Graphic Organizers*

Concept Maps	Mind Maps
Involves expressions of meaning of concepts in a user friendly manner	Meaning of concepts are expressed in graphical form (nodes in graphical form)
Connections between concepts are explicit	Connections between ideas are rarely explicit except one word per branch is used
All morphologies are used	Linear morphologies are involved
Every node-link-node triad forms meaningful propositions	Cannot form propositions
Cross-over are minimized	When cross-connections to hierarchical connections is high (1-10), cross over cannot be easily restructured
Clearly reads one proposition at a time	Propositions are only skimmed to give overview of concepts
Handles less volume of information and conveys information	Handles large volume of information and captures information

Source: Adapted from Dufill (2013); Longanathan (2010)

Perception of students about teaching and learning of chemistry could be described as the way learners understand or interpret the contents of instruction and how it is delivered by the teacher. It is a dynamic element in students' learning process since perception of their activities and roles they played during their learning process could influence their learning outcome (Yuilmazel-Sahin, 2007). Understanding the perceptions held by students regarding the delivery of contents of instruction will provide teachers with valuable information upon which teaching and learning can be modified and as such should be given attention in the realm of science education research (NeSmith, 2003). Students' perception of graphic organizers is vital in order to seek their views on how graphic organizers influence their learning. This is important because their

perception of the graphic organizer would determine what they benefitted from the contents of the organizer and as such influenced what they learn.

Students' perception of a strategy such as graphic organizer instructional strategy provides them with tools to translate, construct and make meanings out of the content of instruction. Some studies have reported that students' perceptions are predictors of their academic achievement (Baek & Choi, 2002; Marchant, Paulison & Rothlisberg, 2001). It is therefore important to investigate students' perceptions about the use of concept maps and mind maps graphic organizers in the present study. Unfortunately, students' perceptions about the usefulness of concept map and mind map graphic organizers are seldom sought by researchers.

Students' perception of a strategy could be influenced by variables such as age, gender, cognitive style among others. Cognitive style is one of the major factors that influence Students' achievement (Cakan, 2000). Cognitive style is an individual's preferred way of thinking and it deals with how that individual processes pieces of information. It reflects the manner or mode of cognition of that individual, revealing the way an individual conceptually organizes his environment. Cognitive styles lay emphasis on typical patterns of psychological functions and processes, and they cut across contents and functions (verbal, numerical, spatial or memory).

Variants of cognitive styles have been identified in literature to exist as pairs. These include: serialist/ holist, impulsivity/ reflectivity, verbalize/ visualize as well as field dependence/ field independence. The pair of field dependence and field independence is the most commonly referred cognitive style in literature probably because they related to an individuals' propensity to approach his environment either in an analytical or global fashion on the basis of their perception about their learning environment (Nozari & Siamian, 2015).

Field independent individuals are able to abstract elements from its context as well as being able to distinguish figures as discrete from their background. This is in contrast with field dependent individuals who approach problems from a global/ broad perspective and are better at recalling information (Altun & Cakan, 2006). However, reports from previous studies revealed inconsistent reports on influence of cognitive styles on students' achievement (Okoronka & Wada, 2014; Sara, Maruta & Olarinoye, 2016).

Gender has been recognized as one of the factors that influence students' achievement in chemistry. Gender is a biological state of existing as either a male or female. Influence of gender on students' academic achievement in science has been a major concern of science educators over a decade. Studies have yielded inconsistent results on gender differences and students' achievement in chemistry. However, studies have indicated that students gender have an influence on their achievement while others noted the superiority of one gender over the other. For instance, Okeke, (2011) reported the superiority of female students over their male counterparts in their achievement in chemistry using mind map instructional strategy while, Ogbonna (2014) submitted that male students achieved better in chemistry than their female equivalents when they were taught using concept map graphic organizer. However, Ariaga and Nwanekezi (2018); Gongden and Delmang (2016) and Chawla and Singh (2015) posited that male and female students do not differ in their achievement in chemistry when taught using concept map instructional strategy. Hence, there is no conclusive evidence on the influence of gender on students' achievement in chemistry especially in the use of graphic organizers. In the present study, the influence of gender on students' achievement in chemistry is being investigated when they are taught using graphic organizers as instructional strategy.

Statement of the Problem

In spite of the importance of chemistry in the school science curriculum, students' performance in senior school certificate chemistry examinations over the years have been less than impressive as their achievement have undulated within the nine year of 2011- 2019 (Table 3). This has raised concern for stakeholders in education especially chemistry teachers and teacher educators. Improvement can be seen for the year 2013 to be above average with 72% credit pass. Years of 2014 – 2016 witnessed a progressive decline to 57%; another boost of 84.8% in 2017 and a sharp decrease to 58% in 2018. Students' performance however, improved to 77.9% in 2019. These figures are undulating and it is expected that a consistent high performance would be more beneficial to the stakeholders. This haphazard results, though not on the very low side (except 2011 and 2012) could be greatly improved.

Table 3

Trends in Students' Performance in WASSCE Chemistry Examinations between 2011 and 2019

Year	Total Entry	Credit Pass (A1 – C6)	Percentage Pass
2011	565,692	280,280	49.54
2012	627,302	270,570	43.13
2013	639,296	462,517	72.34
2014	636,268	397,649	62.49
2015	680,357	412,323	60.60
2016	706,302	408,122	57.74
2017	377,970	320,635	84.83
2018	782,551	424,231	58.22
2019	726,132	566,156	77.96

Source: WAEC, Chief Examiner's Report (2019)

In the West Africa Examinations Council (WAEC) Chief Examiners' report, students were reported to experience difficulties in drawing structures of organic compounds and consistently

have low performance (CER, 2015). It was also noted that questions on organic chemistry were not generally properly attempted by candidates and that this resulted in their poor performances. Furthermore, it was included in the report that candidates generally had difficulties in drawing structures of the organic compounds. The students also could not indicate the functional groups of organic compounds and were unable to properly understand the rubrics of the questions which are based on structures (CER, 2012; CER, 2017). These shortcomings are traceable to students' poor knowledge and understanding of hydrocarbons which unfortunately is a pre-requisite to meaningful understanding of other branches of organic chemistry. For instance, areas such as alkanols and alkanoates have been found to be difficult for students due to poor understanding of hydrocarbons (Adu-Gyamfi, Ampiah, & Appiah 2012). In addition, Agogo and Onda, (2014) reported that secondary school students perceived organic chemistry concepts as been difficult. Since these studies have largely focused on general chemistry topics (and in some cases organic chemistry topics) perceived difficult, there is need to understand the nature of these difficulties and reduce them to enhance deep conceptual learning.

Concept mapping have been suggested by researchers as effective instructional strategies that can be used to help improve students' achievement in organic chemistry. For instance, Arokoyo and Obunwo (2014) adopted a quasi-experimental design to investigate the effect of concept mapping instructional strategy on students' achievement on hydrocarbons (petroleum) and found that students who were exposed to concept mapping had improved performances compared to their counterparts who were taught with the conventional method. However, the study was only limited to teaching of petroleum as hydrocarbon using the concept maps. Moreover, it was not reported in the study that the concept maps were used as an advance organizer. Therefore, the present study probed into using concept maps and mind maps as advance organizer to find out its

effect on students' achievement in hydrocarbons with focus on classes and reactions of hydrocarbons, nomenclature and isomerism in hydrocarbons.

Furthermore, Ariaga and Nwanekezi (2018) investigated the effects of concept mapping on students' performance in organic chemistry. The study adopted a quasi-experimental non-equivalent pre-test post-test non-randomized control group design that involved 141 Senior Secondary School 3 (SSS3) that were selected using multistage sampling technique. It was revealed from findings of the study that students performed better when they were taught using the concept map graphic organizer. The study was limited to the use of quantitative data and the experimental groups were taught to develop their own concept maps. This is in variant with the present study that investigated the use of concept maps and mind maps graphic organizer by adopting the use of quantitative and qualitative data, purposive sampling selection and adoption of a researcher-designed concept and mind map graphic organizer. The adoption of teacher-prepared graphic organizers becomes necessary as studies have reported teaching with a prolonged time when respondents are expected to develop their own maps during lessons (Lok, 2014).

In addition, the present study examined the influence of students' cognitive styles on their achievement when exposed to concept maps and mind maps graphic organizer since they have been reported to be capable of influencing students' performance. Furthermore, it investigated students' achievement when exposed to concept maps and mind maps graphic organizers as an advance organizer for the purpose of providing learners with relevant prior knowledge. This research was limited to collecting quantitative and qualitative data. These data were used in concert with one another to allow triangulation for the purpose of robust data interpretation and this process helped to close gaps in previous studies.

Purpose of the Study

The primary purpose of this study was to determine the effects of the use of graphic organizer on senior school students' achievement in chemistry. Specifically, the study investigated the:

1. effect of the use of concept map graphic organizer on secondary school students' achievement in organic chemistry
2. effect of the use of mind map graphic organizer on secondary school students' achievement in organic chemistry
3. difference in the achievement of secondary school students in organic chemistry when taught using concept map graphic organizer and when taught using mind map organizer.
4. perception of secondary school students on the use of concept map graphic organizer in learning organic chemistry
5. perception of secondary school students on the use of mind map graphic organizer in learning organic chemistry
6. influence of gender on secondary school students' achievement in organic chemistry when taught using concept map graphic organizer
7. influence of gender on secondary school students' achievement in organic chemistry when taught using mind map graphic organizer
8. influence of cognitive styles on secondary school students' achievement in organic chemistry when taught using concept map graphic organizer
9. influence of cognitive styles on secondary school students' achievement in organic chemistry when taught using mind map graphic organizer
10. influence of gender on secondary school students' perception on the use of concept map graphic organizer in learning organic chemistry

11. influence of gender on secondary school students' perception on the use of mind map graphic organizer in learning organic chemistry
12. influence of cognitive styles on secondary school students' perception on the use of concept map graphic organizer in learning organic chemistry
13. influence of cognitive styles on secondary school students' perception on the use of mind map graphic organizer in learning organic chemistry
14. Experience of secondary school students on their exposure to organic chemistry when taught using of concept map graphic organizer.
15. Experience of secondary school students on their exposure to organic chemistry when taught using of mind map graphic organizer.

Research Questions

The following research questions were answered in this study;

1. What is the effect of the use of concept map graphic organizer on secondary school students' achievement in organic chemistry?
2. What is the effect of the use of mind map graphic organizer on secondary school students' achievement in organic chemistry?
3. What is the difference in the achievement of secondary school students that were taught organic chemistry using concept map graphic organizer and those taught using mind map graphic organizer?
4. What are the perceptions of students on the use of concept map graphic organizer in learning organic chemistry?
5. What are the perceptions of students on the use of mind map graphic organizer in learning organic chemistry?

6. What is the influence of gender on secondary school students' achievement in organic chemistry when taught using concept map graphic organizer?
7. What is the influence of gender on secondary school students' achievement in organic chemistry when taught using mind map graphic organizer?
8. What is the influence of cognitive styles on secondary school students' achievement in organic chemistry when taught using concept map graphic organizer?
9. What is the influence of cognitive styles on secondary school students' achievement in organic chemistry when taught using mind map graphic organizer?
10. What influence does secondary school students' gender have on their perception on the use of concept map graphic organizer in learning organic chemistry?
11. What influence does secondary school students' gender have on their perception on the use of mind map graphic organizer in learning organic chemistry?
12. Does secondary school students' cognitive styles influence their perception on the use of concept map graphic organizer in learning organic chemistry?
13. Does secondary school students' cognitive styles influence their perception on the use of mind map graphic organizer in learning organic chemistry?
14. What are the experiences of students on their exposure to organic chemistry when taught using the concept map graphic organizer?
15. What are the experiences of students on their exposure to organic chemistry when taught using the mind map graphic organizer?

Research Hypotheses

The following null hypotheses were tested at 0.05 level of significance.

H₀₁: There is no significant difference in the achievement of secondary school students taught organic chemistry using concept map graphic organizer and those taught using the conventional method.

H₀₂: There is no significant difference in the achievement of secondary school students taught organic chemistry using mind map graphic organizer and those taught using the conventional method.

H₀₃: There is no significant difference in the achievement of secondary school students' inorganic chemistry when taught using concept map graphic organizer and those taught using mind map graphic organizers.

H₀₄: There is no significant difference in the achievement of male and female secondary school students when taught organic chemistry using concept map graphic organizer.

H₀₅: There is no significant difference in the achievement of male and female secondary school students when taught organic chemistry using mind map graphic organizer.

H₀₆: There is no significant difference in the achievement of field dependent and field independent secondary school students in organic chemistry when taught using concept map graphic organizer

H₀₇: There is no significant difference in the achievement of field dependent and field independent secondary school students in organic chemistry when taught using mind map graphic organizer

H₀₈: There is no significant difference in the perception of male and female secondary school students on the use of concept map graphic organizer in learning organic chemistry

H₀₉: There is no significant difference in the perception of male and female secondary school students on the use of mind map graphic organizer in learning organic chemistry

H₀₁₀: There is no significant difference in the perception of field dependent and field independent students on the use of concept map graphic organizer in learning organic chemistry

H₀₁₁: There is no significant difference in the perception of field dependent and field independent students on the use of mind map graphic organizer in learning organic chemistry

Scope of the Study

The study was limited to SS2 students in chemistry in Ilorin, metropolis this is because they are expected to be taught organic chemistry at this level. The study focused on the effect of the use of two graphic organizers (concept maps and mind maps) on senior school students' achievement in chemistry. Specifically, the study examined the effects of presenting instruction with concept and mind maps graphic organizers to teach organic chemistry. The choice of these maps was because they were considered to be suitable to teach the contents of instruction (hydrocarbons) due to the complexity of the topic and its relationship with alkanols, alkanoic acids, and alkanoates.

The content area of investigation is hydrocarbon because it is one of the most difficult areas in chemistry. Besides, hydrocarbon is prerequisite to the understanding of various aspects of organic chemistry. Students' gender and cognitive styles were investigated as variables. This was because previous researchers identified them as possible variables capable of influencing students' achievement.

Significance of the Study

It is anticipated that the findings of this study would be of benefit to chemistry students, teachers, curriculum developers, textbook authors/ publishers, teacher educators, Science Teachers

Association of Nigeria (STAN), government agencies for instance Teachers Registration Council of Nigeria (TRCN) and researchers in the field of education.

The outcome of this study would help to explain the role of graphic organizers in the enhancement of students' understanding of the organic chemistry topic of hydrocarbons. Its outcome would benefit chemistry students as it would stimulate in them the skill of using mapping strategies which eventually would improve their achievement in chemistry. This would further increase their motivation in studying the subject of chemistry, especially organic chemistry. Students would also be able to adopt the use of concept and mind maps as study tools to construct knowledge towards enhancing meaningful learning in other difficult topic areas by fostering understanding of interrelated concepts.

Findings from this study would be of help to teachers by giving them insight into the nature of graphic organizers and how these can be used to teach hydrocarbons and other difficult topics in chemistry. The outcome of this study would thus provide curriculum developers with factual information that would guide them in recommending the use of graphic organizers to teach difficult topics in the chemistry curriculum.

Textbook authors and publishers would benefit from the outcomes of this study as it would help them to improve their presentations of concepts in hydrocarbons an area which students' perceive difficult for meaningful learning. Since curriculum documents undergo periodic review in the light of new and consistent research outcomes, the outcome of this study would inform the inclusion of the use of graphic organizers as tools that teachers and students engage in and learning of hydrocarbons.

The findings of this study have come up with empirical evidence for teacher educators in deciding whether or not to utilize graphic organizers in the training of pre-service chemistry teachers as effective instructional strategies.

Clarification of Major Terms and Variables

The following terms and variables are clarified as used in this study.

Advance Organizer: an instructional unit that is presented to learners prior to instruction. It utilizes students' prior knowledge. It does not give a summary of the content of instruction but bridges the gap between prior knowledge and the new learning material.

Graphic Organizer: visual display that illustrates relationship between concepts, facts and ideas in a spatial form. In this study, they are concept maps and mind maps graphic organizer which are examples of conceptual graphic organizers

Concept Maps: spatial arrangement of chemistry concepts which shows the relationship among concepts. The most general concept is placed at the top of the map and is characterized by the presence of linking words to show relationships among concepts.

Mind Maps: spatial arrangements of chemistry concepts which include: verbal and symbolic elements. The most general concept is placed in the middle of the map and lacks linking words that indicates the relationships that exist among concepts.

Perception: the way learners viewed and understood the role of the graphic organizers that they were exposed to when studying organic chemistry.

Hydrocarbons: the facet of organic chemistry that provides insights to the study of compounds which contain carbon and hydrogen. They are the pre-requisite for understanding other aspects of organic chemistry

Cognitive Style: senior secondary school chemistry students' preferred way of processing information. It could be field dependent or field independent.

Field independent cognitive style: are students who are able to extract elements from its context and discern figures from a distinct background in the Group Embedded Figure Test (GEFT)

Field dependent cognitive style: are students who are unable to abstract elements from its context but however approach problems from a broad perspective

Group Embedded Figure Test (GEFT): a non-verbal test that was administered to learners for the purpose of grouping them into their cognitive styles

CHAPTER TWO

REVIEW OF RELATED LITERATURE

This chapter deals with a review of related literature. It is being carried out under the following subheadings:

- Theoretical Framework of the Study
- Objectives and Content of Senior Secondary School Chemistry Curriculum
- The Nature and Role of Graphic Organizers in Teaching and Learning
- Empirical Studies on Innovative Strategies and Students' Achievement in Organic Chemistry
- Empirical Studies on Graphic Organizers and Students' Achievement in Science
- Empirical Studies on Concept Maps and Students' Achievement in Chemistry
- Empirical Studies on Mind maps and Students' Achievement in Science
- Studies on Students' Perception on the use of Graphic Organizers in Teaching and Learning
- Studies on the Influence of Cognitive Style and Academic Achievement of Students in Science
- Studies on Influence of Gender on Students' Achievement in Chemistry
- Appraisal of Reviewed Literature

Theoretical Framework of the Study

The theory which supports this study stems from Jean Piaget's constructivism theory and Paivio's dual coding theory. A constructivist theorist views learning as one in which learners are the active agent in the process of acquiring knowledge. That is, cognition is as a result of mental construction in which students learn by relating new information with what they already have in their cognitive structure. Constructivism is a philosophical view of how learners construct,

understand and know information. This philosophical view is based on three primary propositions which are;

- i. Learners' understanding is in their understanding of their environment;
- ii. Cognitive conflict is the spur for learning and it influences the organization and nature of what is learned; and
- iii. Knowledge progresses through social negotiation and the evaluation of the feasibility of individual understanding (Savery & Duffy, 2001).

The constructivist theory has its roots in the works of Dewey (1929), Brunner (1961), Vygotsky (1962) and Piaget (1980). For Instance, Piaget opined that cognitive development takes place through a pattern of successive qualitative changes in cognitive structures. Constructivist theorists are of the opinion that learning is affected by the context in which an idea is taught and also by the attitude and beliefs of the learners. This learning theory is rooted in psychology and it centered on how students acquire knowledge and comprehend. Two major concepts within the theory is accommodation and assimilation. The theory proposes that humans construct knowledge and make meanings from their personal experiences.

Constructivist teaching is based on research on the human brain. For instance, the human brain processes two types of knowledge based on cognitive agreements: verbalizable knowledge of "knowing what" (declarative knowledge) and the knowledge of knowing how to manipulate or perform a certain task (procedural knowledge). The latter requires the higher order thinking process of synthesis, application, and analysis (Anderson, 1983). The understanding of how this knowledge interacts to organize knowledge for meaningful learning is a significant tool in the teaching and learning processes. It becomes imperative to indicate that declarative knowledge is a prerequisite to the acquisition of procedural knowledge. Therefore, it can be stated that the

declarative knowledge provides the basis for which procedural knowledge exist (Gil-Garcia & Villegas, 2003).

Transition from declarative knowledge to procedural knowledge requires a structural knowledge (Diekhoff, 1983). The connection between the declarative and structural knowledge is associated with independent ideas that the learners possess and which is a process of reframing “knowing what” to “knowing why” (Gil-Garcia & Villegas, 2003). When structural knowledge is developed, learners tend to understand the relationship among ideas. Consequently, the connection of ideas that are created by structural knowledge is pivotal to developing procedural knowledge (Ritchie & Gimenez, 1995). It is on this premise that an advance organizer finds its base as material that can assist learners to develop their structural knowledge. Graphic organizers which can be used as an advance organizer are spatial or visual representation of instructional contents which show the relationships among concepts in a node-link-visual display (Anderson, 1990). These organizers link new learning materials to prior knowledge in the cognitive structure in order to facilitate the comprehension of new knowledge.

Advance organizers are credited to David Ausubel who was inspired by the works of Jean Piaget. Ausubel (1960) believed in the idea of meaningful learning. It is claimed that the major factor that influences learning is what learners are already familiar with. This implies that construction of knowledge begins with learners’ observation and recognition of events and concepts that already exist in their cognitive structure. It was also noted that knowledge is organized in hierarchy and new information is meaningful to the extent in which learners can relate it with what they already know. According to this perspective, learning proceeds in a deductive manner and advocating for the use of advance organizers will provide mechanism that helps link new materials with existing related ideas in the learners’ cognitive structure.

The dual coding theory of cognition was developed by Paivio (1986). The theory assumes that the brain consists of two separate but interrelated systems for processing information which is verbal association and visual imagery (Wills & Ellis, 2008). Each of the systems can be initiated independently and can be used to represent information. Visual and verbal information are processed differently in the human mind thereby creating separate representations for information processed in each channel in form of mental codes (analogue or symbolic codes). The mental codes corresponding to information are used to systematically order incoming information and can be retrieved for subsequent use while recalling information (Sternberg, 2006). The dual coded information is easier to retain and recall due to the presence of two mental representations. Therefore, students think and recall information better when they use both forms together (Marzano, Pickering, & Pollock, 2001).

This theory has a direct effect on the use of graphic organizers as a visual tool since it projects a non-verbal representation of the content of instruction to learners. This non-verbal representation makes it possible for learners to generate a verbal interpretation of the organizer. The graphic organizer as a visual tool enables students to process and remember contents of instruction by facilitating the development of mental images and thereby creating verbal information thereby dual coding contents of instruction.

Objectives and Content of Senior Secondary School Chemistry Curriculum

The curriculum has been defined by several scholars in education (Olorundare, 2014; Eisner, 2002). Olorundare (2014) defined curriculum as structured series of learning outcome which engirdle the framework of what to learn and how it should be learned. Eisner (2002) elucidated that the curriculum is a series of planned events that are intended to have educational significance for the learners. The chemistry curriculum in use in Nigerian secondary schools in

recent times was last revised in 2008 by the Nigerian Educational Research and Development Council (NERDC). The objectives of the senior secondary school chemistry curriculum were adopted from the National Policy on Education. These objectives include enabling students to;

- i. develop interest in chemistry;
- ii. earn fundamental theoretical/practical knowledge and expertise;
- iii. develop interest and acquire fundamental knowledge and expertise in science, technology and mathematics;
- iv. develop reasonable knowledge in information, communication technology (ICT) applications that will give rise to entrepreneurial skills;
- v. apply expertise to meet societal demands of creating employment and wealth;
- vi. be positioned to take edge in the diverse career opportunities offered by chemistry; and
- vii. be sufficiently prepared for further studies in chemistry.

In addition, the reviewed senior secondary school chemistry curriculum will;

- i. Enable an even transition in the use of scientific concepts and techniques acquired in the basic science and technology curriculum with chemistry;
- ii. provide students with fundamental knowledge in chemical concepts and principles through selection of contents and sequencing in a well-organized and competent way;
- iii. show chemistry and its interrelationship with other subjects
- iv. show chemistry and its links with industry, everyday life activities and hazards
- v. make provision for a complete course for students who are not going to proceed to higher education while at the same time provide sufficient foundation for further studies in chemistry course.

Source: NERDC, 2008.

The selection of the contents for chemistry curriculum was done considering issues such as globalization, ICT, and entrepreneurship. The contents of the curriculum focused on practical activities with emphasis on locally available materials. This is to foster the spirit of inquiry in chemistry students. For Nigeria to be associated with contemporary development, the contents of the chemistry curriculum are organized under four themes. These themes are;

- i. The Chemical World
- ii. Chemistry and Environment
- iii. Chemistry and Industry
- iv. Chemistry and Life

Effective implementation and ensuring attainment of objectives of the curriculum requires that chemistry teachers are vastly knowledgeable in chemistry contents, and also the philosophy and purpose of the curriculum. Hence, the curriculum was designed to indicate explicitly the four themes in the three years of secondary level of education. It included the topics that are arranged in a spiral form, performance objectives of each topic, contents of the topic, teacher and students activities, teaching and learning materials as well as evaluation guide. Table 4 shows a summary of the contents of the secondary school chemistry curriculum.

Table 4*Contents of Senior Secondary School Chemistry Curriculum*

Year	Themes	Topics
SS1	Chemistry and Industry The Chemical World	Chemical industry Introduction to Chemistry, Particulate nature of matter, symbols, formulae and equations, chemical combination, gas laws
	Chemistry and Environment	Standard separation techniques for mixtures, acid bases and salts, water,
	Chemistry and Life	Carbon and its compounds,
SS2	Chemistry and Industry	REDOX reactions, ionic theory, electrolysis
	The Chemical World	Periodic table, chemical reactions, mass, volume relationships, acid base reactions
	Chemistry and Environment	Water, air, hydrogen, oxygen, halogens, nitrogen, sulphur
	Chemistry and Life	Hydrocarbons, alkanols
SS3	Chemistry and Industry	Petroleum and crude oil, metals and their compounds, iron, ethical, legal and social issues
	The Chemical World	Quantitative and qualitative analysis
	Chemistry and Environment	NIL
	Chemistry and Life	Fats and oils, soaps and detergents, giant molecules,

Source: Adapted from Senior Secondary School Chemistry Curriculum, NERDC, 2008

In recognition of fact that Nigeria secondary schools operate an examination oriented education system, examination bodies such as WAEC and NECO present to schools what should be focused on in form of syllabus, subject matter content and required skills that should be developed in students. Since the syllabus is a subset of the curriculum, it is assumed that the

curriculum is invariably implemented when schools meet up with the requirements of the syllabus provided by the examination bodies (Olorundare, 2014).

The aims and objectives of the WASCCE chemistry syllabus include assessing candidates’:

- i. comprehension of fundamental chemistry concepts;
- ii. extent of acquisition of laboratory skills which includes cognizance of hazard and safety measures;
- iii. extent of consciousness of the interrelationship between chemistry and other disciplines;
- iv. extent of awareness of the relatedness between chemistry and industry, environment, everyday life in terms of benefits and hazards; and
- v. expertise of critical and logical thinking.

Source; WAEC Syllabus, 2017.

The contents of the syllabus are in three sections: section A includes contents for all candidates, Section B for candidates in Ghana only while Section C for candidates in Nigeria, Liberia, Sierra- Leone, and The Gambia. Table 3 presents the content of the WASSCE chemistry syllabus.

Table 5*Contents of the West Africa Senior Secondary Certificate Examinations Syllabus*

Sections	Topics
Section A	Introduction to chemistry, structure of atoms, standard separation techniques for mixtures, periodic chemistry, chemical bonds, stoichiometry and chemical reactions, states of matter, energy and energy changes, acids, bases and salts, solubility of substances, chemical kinetics and equilibrium system, REDOX reactions, chemistry of carbon compounds, chemistry of industry and environment, basic biochemistry and synthetic polymers
Section B	Applicable to candidates in Ghana
Section C	Non- metals and their compounds, metals and their compounds, practicals (quantitative and qualitative analysis)

Source: Adapted from West Africa Examinations Council Syllabus (2017).

The focus of the present study, hydrocarbons comes under the topic ‘chemistry of carbon compounds’. The topic requires that students are taught structure and valency of carbon atom, meaning and examples of hydrocarbon, homologous series, composition and structure of saturated and unsaturated hydrocarbons, isomerism, and aromatic hydrocarbons (benzene structure and properties only). This is however similar to what is stated in the examination syllabus with inclusion of teaching topics such as: nomenclature, alicyclic hydrocarbons, sources of hydrocarbons, differences between structural and geometric/stereo isomerism, reactivity, combustion, substitution reactions and cracking of large alkane molecules. For the purpose of this study the researcher utilized the contents of hydrocarbons in the WASSCE syllabus. This is because it is more elaborate than what is available in the curriculum. Also, it is due to the fact that chemistry teachers structure the scheme of work from the syllabus and this form the basis for the development of lesson plan.

The Nature and Role of Graphic Organizers in Teaching and Learning

Students tend to remember more of what they see than what they read about in texts. They also tend to understand what they feel and engage in during learning processes. Sensory abilities therefore are powerful parts of the brain functioning (Antoine, 2013). Teachers can make optimum use of these abilities in their classrooms to improve students' comprehension and preservation of information. Visual organizers (such as graphic organizers) are important tools in teaching, learning and assessment in classrooms. This is due to their ability to aid learners' in creating knowledge when they connect disorganized information to make such information meaningful in form of maps (Wolfe, 2001). They assist students to establish relationships among keywords in a lesson, and teachers also utilize them to assess students' understanding by viewing completed organizers by the students. Miller (2011) asserted that graphic organizers help students to systematically order their thoughts and apply their thinking skills to new learning materials in a more organized manner.

Graphic organizers are visual tools that show relationships among concept and ideas in a structural form. They are creative techniques that are used to present complex information in a simple and meaningful graphic display (Kang, 2004). They could be used by teacher prior, during or after teaching a new learning material. They can be described as agendas that give students an idea of what they will be learning (Meera & Aiswarya, 2015). Hence, they should be simple, clear as much as possible since they are powerful tool that can be part of a supportive classroom environment and integrative instruction.

Graphic organizers have also been described as visual and spatial representations that show interconnections between related facts and concepts (Gajria, Jitenda, Sood & Sacks, 2007). They are visual and learning tools that show organization of concepts and their relationship in a visual

format. The visualization of the material enables students to learn the new learning material as a whole rather than in pieces (Katayama, Robinson, Devaney & Dubois, 1997). The visual representation of graphic organizer provides learners with a structural framework of information to be learned by directing their attention to key concepts and relationships between the concepts. Hence, helps students to clearly identify how ideas are organized and/or related within a surrounding and key concept (Baxendell, 2003). Graphic organizers therefore, can be used to alleviate difficulties and assist weak learners to make effective meaning from a given idea or topic (Ching & Chee, 2010).

Graphic organizers tend to facilitate understanding and promote meaningful learning of new materials by making abstract concepts more concrete. These abstract concepts are concretized by connecting new information (new learning material) with prior knowledge in the learners' cognitive structure (Ausubel, 1968; Mayer, 1979). They can be used at the beginning of a lesson, as a teaching tool throughout the lesson or for a review in future (Ayverdi, Nakiboglu & Aydin, 2014). They can be introduced as advance organizers and students are made to complete the prior knowledge portion while the teacher makes reference to it throughout the lesson.

As students review graphic organizers studied in the past, the review spurs their prior knowledge to be activated. Thus, they are able to recall and analyze information as they visualize the graphic organizers that have been committed to memory (Ben-David, 2002). Graphic organizers are originally called advanced organizers whose purpose is to activate students' prior knowledge and assist them to focus on how concepts are interrelated rather than focusing on making association or memorizing isolated facts (Chang, Sung & Chen, 2002). By so doing, it provides optimal anchorage and makes the new learning material more familiar and meaningful to

the students. Graphic organizers are linked to schema theory which emphasizes the importance of connecting new information to prior knowledge.

A learner tends to comprehend information if he/she finds related information in his/her cognitive structure. The new information is accepted (accommodated) or may alter the existing ones in the learners' cognitive structure to accommodate the new knowledge (Anderson & Pearson, 1984). Graphic organizers give students the likelihood to recall information from the memory and such detail is linked to a newly gained information which consequently generates a relational knowledge that is sequel to meaningful learning (Goddard, Pring & Felminghan, 2005; DiCecco & Gleason, 2002). However, Stull and Mayer (2007), asserted that the increased activity of learners in creating and using graphic organizers should not be interpreted as deep learning (that is should be categorized in the lower levels of the Bloom's taxonomy) but would still be considered as learning.

Varieties of terminologies have been used to elucidate graphic organizers. Such terms include: visual displays, graphic(al) representations or displays, graphics, tree diagrams, network representations, structured overviews, matrix, adjunct displays/ aids among others (Manoli & Papadapoulou, 2012). There are various types of graphic organizers with extensive collection of patterns, shapes and formats that can be selected by the teachers and learners to fit the concept that they are studying. Six types of graphic organizer patterns are identified by Gill-Garcia (2003). They are: hierarchical, conceptual, sequential, relational, evaluative and cyclical. The organizational patterns of text are contained in Figure 1. The selection of any of these patterns as identified by the researcher includes: the complexity of the text, fitness to the curriculum content and its structural pattern should agree with the organizer selected.

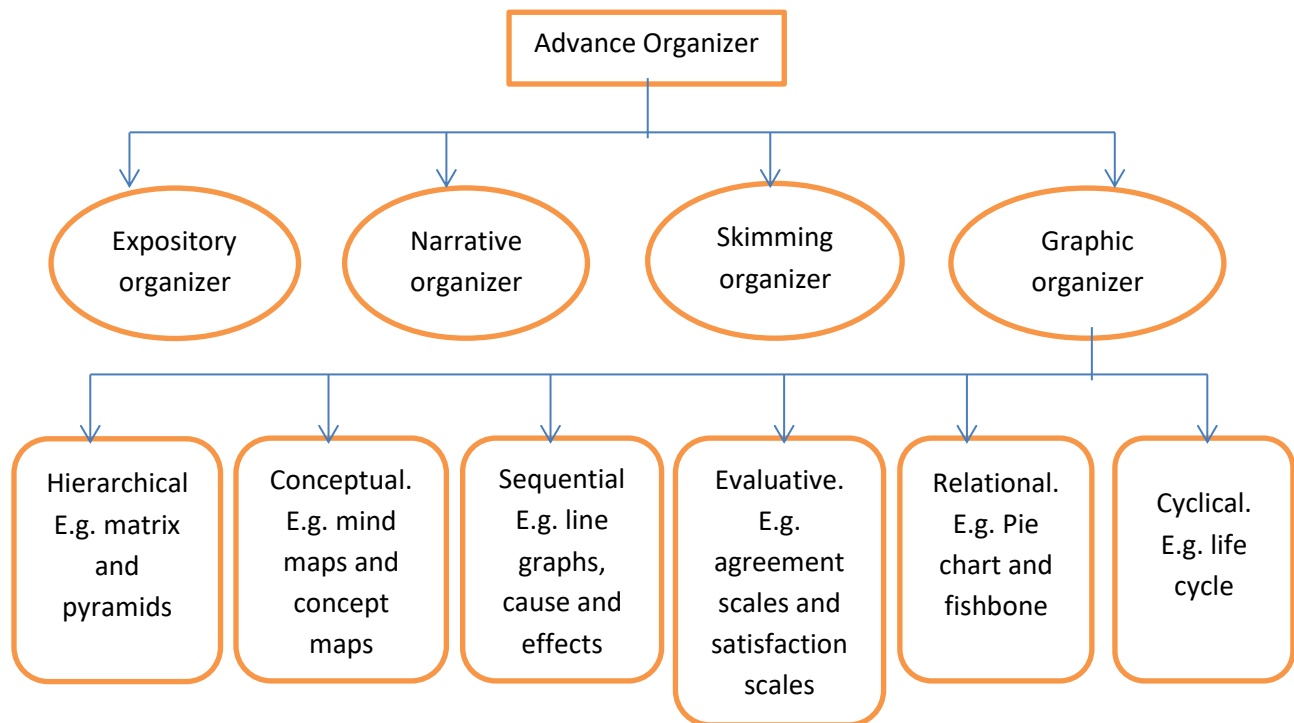


Figure 1: Forms of Advance Organizers.

Graphic organizers have been found to improve the quality of teaching and learning. Its role includes but not limited to the following:

- (a) Connecting the type of knowledge (declarative or procedural) that the teacher intends to establish in students' reasoning.
- (b) Used by both teacher and students to prepare new information for integration to the familiar information in the learners' cognitive structure.
- (c) Providing students with effective learning processes in terms of linking, transferring, and storing information in their schemata.
- (d) Enhancing the activation of students' prior knowledge of the topic taught
- (e) Allowing learners to acknowledge and share their understanding of the lesson objectives.

- (f) Familiarizing the learners with the information in the text by making it available to them prior to reading (Gill-Garcia, 2003; Ellis & Howard, 2005).

Since effective teaching and learning requires that teachers activate the prior knowledge of their learners, it is imperative that they utilize efficient tools that will bring forth students' prior knowledge and establish linkages between the prior knowledge and new learning materials. Science generally, is attributed to abstract concepts, which requires application of ideas and practical activities. These concepts are interrelated and its contents may be overwhelming if meanings and relationships between the concepts are not established. Therefore, there is need to adopt a teaching and learning tool such as graphic organizers that can assist learners in a typical science lesson (Kinniburg & Shaw, 2007).

Empirical Studies on Graphic Organizers and Students' Achievement in Science

Graphic organizers are visual advanced introductory material in spatial forms which are presented to students prior to the introduction of new learning material. They bridge the gap between the new learning material and prior knowledge. In cases where prior knowledge is not available in the cognitive structure, organizers serve as the prior knowledge in which students fall back on. Hendron (2003) reported that students perform better when they use graphic organizer due to the way it scaffolds new ideas with pre-existing schema. Graphic organizers link previous knowledge with the new learning material. It is not a teaching method on its own but a teaching strategy needed to help clarify science concepts that students learn. However, it has been observed that different forms of organizer yield different results (Gil-Garcia & Villegas, 2003).

Over the years, research has been carried out to find out effects of various types of graphic organizers in chemistry (Bamidele, Adetunji, Awodele, & Irinoye, 2013; Chabari, Wachanga, & Anditi, 2018; Ekenobi, Mumuni & Nwanekezi, 2016; Ekenobi & Mumuni, 2015; Oloyede, 2011;

Torres, Espana & Orleans, 2014; Wachanga, Arimba & Mbugua, 2013). Their works concentrated on the effects of graphic organizer with expository organizers on the achievement, retention and the efficacy of students incorporating gender as moderator variable. Bamidele, Adetunji, Awodele, and Irinoye (2013) investigated the comparative effectiveness and attitude of secondary school students towards the use of hierachial, flow chart and spider maps as advance organizer in teaching the mole concept. The study was a pre-test post-test control group quazi experimental design. The sample for the study was 132 respondents in three intact classes from three randomly selected government secondary schools in Osun State. The schools were randomly assigned into treatment groups respectively and there was no control group. Instrument utilized in the study were instructional packages for the three mapping strategies, problem solving achievement test and attitude questionnaire.

Students in the three experimental groups were provided with the maps prior to teaching them to see the relationships between concepts placed on the maps. Topics covered included the mole, chemical equations, stoichiometry, gas laws and calculations involving gas volumes, solubility and electrolysis. The treatment span was a period of five weeks. Data gathered were analyzed using one way ANOVA. The findings specified that there was no significant difference in the pretest scores of the groups; this indicates that the groups were equivalent before subjecting them to treatments. Findings also revealed that there was no significant difference in the performance of students exposed to the three different mapping strategies. Therefore, using any of these mapping strategies may have similar effect on students' performance in chemistry.

Chabari, Wachanga, and Anditi, (2018) conducted a study to determine the effects of graphic organizer experiential teaching approach on secondary school students' achievement in chemistry. Specifically, chemical structure and bonding were the contents covered in the study.

The study adopted a Solomon four non-equivalent control group design and the sample involved 216 year two students who were purposively selected. The respondents were in four intact classes in Sub-County public schools in Kenya. The four classes were in streams of two experimental groups and two control groups. The research instrument utilized was a chemistry achievement test which contained 30 items. The study lasted for four weeks and students in the experimental group were guided on how to construct graphic organizers in groups while the control groups were taught using the traditional approach.

Data collected were analyzed using t-test, ANOVA and ANCOVA at 0.05 level of significance. Findings revealed that there was a significant difference between the achievement of students in the experimental and those in the control group. This difference was reported to be in favour of the experimental group. Results also, revealed that there was no significant difference between students' achievement in the two experimental groups when they were taught using graphic organizer experiential teaching approach. The study therefore, concluded that graphic organizer experiential teaching approach enhanced students' learning in chemistry.

Ekenobi and Mumuni (2015) investigated the efficacy of graphics and textual organizer instructional strategy on chemistry students' cognitive achievements in concepts related to redox reaction in Rivers state, Nigeria. Their study adopted a pre-test post-test control group quasi experimental design that involved a sample of 220 senior school chemistry students. The sample comprises of 118 males and 102 females who were purposively selected from three public co-educational senior secondary schools. The study involved three groups: two experimental (graphics and textual advance organizer) and a control group taught with expository presentation approach.

A redox reaction chemistry achievement test was used to collect data for the study. However, the difficulty and discrimination indices were not reported. The chemistry achievement test contained 40 items that test the lower and higher level of cognitive domains based on Bloom's taxonomy. The lower level of cognitive domain (knowledge and comprehension) had 30% of the items while the remaining 70% tested the higher levels of cognitive domain. Data gathered were analyzed using mean, standard deviation, and two-way ANCOVA at 0.05 level of significance.

Findings from the study disclosed that graphic organizer improves students' achievement in chemistry followed by the textual organizer while, the control group had the least achievement at the various cognitive levels. Findings from the study also indicated that significant difference existed in the performance of the three groups in the lower and higher levels of cognitive domain with the graphic organizer contributing on the high side to the difference. It was also observed that there was no significant difference in the achievement of male and female students' when exposed to graphic and textual organizers. It was concluded that the graphic organizer was the most efficacious strategy in enhancing students' achievement, and that gender had no significant influence on the students' performance in the chemistry achievement test.

Oloyede (2011) conducted a study on the effect of pictorial and written advance organizer on students' achievement and retention in the concept of energy change among SS2 students in chemistry in Bauchi, State. Five schools that were selected with criterion sampling technique were involved in the study (three experimental groups and two control groups). The study involved three groups (pictorial, written and control group) with a sample size of 138 participants. A pictorial organizer package, written organizer and a chemistry achievement test that comprised 50 multiple choice questions were developed by the researcher as research instrument for the study.

Data gathered from the study were analyzed using t-test, multiple correlation and ANCOVA. Gender and retention of the respondents after being exposed to the various treatments were compared. The outcome of the study indicated that the group taught with pictorial organizer performed significantly better than the group taught with written organizer while the control group had the least achievement score. It was also observed that the pictorial organizer was more effective in enhancing students' retention in the chemistry achievement test than the written organizers and there was no significant difference in the performance of male and female students' achievement in the pictorial and written organizer group.

Torres, Espana, and Orleans (2014) investigated the attitude and achievement of freshmen students in learning selected topics chemistry when they were taught with to graphic organizers. The topics were selected based on the content requirements as specified in the course syllabus and information. The graphic organizers considered in the study were web and venn diagrams, flow charts and pictorial forms. The study utilized a mixed method (descriptive method and quasi experimental design) that involved two intact classes. However, the groups involved were within the same school environment, and this could cause contamination of information between the groups.

Three research instruments (attitude questionnaire, perception questionnaire and a chemistry achievement test) were used to collect data for the study. Mean was used to answer the research question while t-test and ANCOVA were used to test the hypotheses at 0.05 level of significance. Findings from the study indicated that students' performance improved significantly after exposure to the treatment. Also, students possessed positive attitude towards chemistry and a good perception of the use of graphic organizer in teaching and learning. It was noted in the study

that a validation process was not carried out on the instrument and which was a limitation in the study.

Wachanga, Arimba, and Mbugua (2013) investigated the effect of advance organizer on students' achievement in the mole concept. The concept examined in the study include the mole, relative atomic and molecular masses, empirical and molecular formulae, molar solutions, chemical equations, titration and molar gas volume. The study adopted Solomon four non-equivalent control group design. A chart in form of graphic organizer and a chemistry achievement test were used as instrument in this study. Purposive sampling technique was utilized to select four co-educational secondary schools in Maara District, Kenya. Data gathered were analyzed using descriptive statistics of mean, standard deviation and the percentage while inferential statistics of t-test, one-way ANOVA and ANCOVA were utilized to test the hypotheses raised in the study.

Findings from the study revealed that the experimental groups benefitted most from the treatment than their counterparts in the control groups. Also, the findings revealed no significant difference in the performance of male and female students after being exposed to the treatment. However, it could be deduced from the study that the mole concept was taught for eight weeks which seems to be too lengthy a time although, there were seven subtopics. The test items utilized in the study contained 10 items that only tested four out of six learning domains (knowledge, comprehension, application and analysis excluding synthesis and evaluation). The difficulty and discrimination indices of the test items were also not reported. This notwithstanding, the internal consistency of the test instrument was high above the threshold and was considered reliable for the study.

Akinbobola (2015) conducted a study to determine the effects of pictorial, written and verbal organizer on students attitude in physics in Osun State, Nigeria. The study adopted a 4X2

quasi experimental design. Four groups were involved in the study out of which three of the groups served as the experimental group (pictorial, written and verbal organizer) and a control group. The four groups were taught the concept of heat transfer. The organizers utilized in this study were designed to include subsumers that are related to the concepts of energy which included; forms of energy, sources of energy, energy conversion and applications of energy conversions. Also, a questionnaire titled: Attitude Towards Physics Questionnaire (ATPQ) and researcher-developed organizers for all the groups were the research instruments utilized in the study.

Data gathered for the study were analysed using descriptive statistics (mean and standard deviation), while inferential statistics (t-test and ANCOVA) were used to test hypotheses raised in the study. Analysis of data revealed that the various forms of advance organizer (pictorial, written and verbal organizer) were effective in bringing about attitudinal change among the respondents. Specifically, the pictorial organizer was reported to be more potent, followed by the written organizer and lastly, the verbal organizer. Also, there was no significant difference in the attitude of male and female students' when taught with the various forms of advance organizer.

Udo and Ubana (2013) in an earlier study had determined the effect of graphic organizer on students' retention in current electricity in physics in Cross River State. The study adopted a quasi experimental design and involved two intact groups that were purposively selected. The two groups were randomly assigned experimental and control groups respectively. The instrument utilised for data collection is a graphic organizer and a chemistry achievement test developed by the researcher. The treatment lasted for two weeks after which a retention test was administered at two weeks interval from the post test. Data were analysed using ANCOVA and findings from the study indicated that graphic organizer aided students' retention in physics and the difference between male and female students' retention score was found not to be significant.

Owolabi and Adaramati (2015) examined the effects of graphic organizer on students' achievement in algebraic word problems among SS2 students in Lagos State. They adopted a pre-test post-test non-equivalent control group design. The study involved two experimental groups and a control group. The first experimental group was taught with graphic organizer, the second experimental group was taught how to design an organizer while the control group was taught using the conventional method. Findings revealed that the experimental groups performed better than the control group. Specifically, experimental group two (taught to design organizer) had the highest mean gainscore. The male students were found to benefit more from the treatment than the females and the difference was not found to be statistically significant. This finding corroborates those of Akinbobola (2015) and Oloyede (2011) who reported the effectiveness of graphic organizer over textual organizers and, no significant difference between male and female students' performance when taught with graphic organizer.

A brief overview of the reviewed literature indicates dearth of research on the effect of conceptual patterns of graphic organizer with emphasis on concept and mind maps taking into consideration the effect of these organizers on students' achievement based on gender and cognitive styles. Therefore, this study will fill the existing gap to find out the effects of concept and mind map graphic organizer on students' achievement in chemistry considering the cognitive styles of respondents. Also, the influence of cognitive styles and gender were considered as moderator variables in this study. This is because both variables had been reported to influence students' performance in chemistry (Idika, 2017; Popoola & Olorundare, 2017).

Empirical Studies on Concept Maps and Students' Achievement in Chemistry

Concept maps have reportedly been identified in literature as one of the instructional strategies that can be utilized in teaching and learning difficult concepts in chemistry. It can be

used as teaching tool when teachers adapt it in presenting contents of instruction to learners. Also, students can utilize it as study tools when they construct their own maps before or after a new content is taught to them.

A number of studies have been carried out to investigate the effectiveness of concept maps in teaching/learning of chemistry (Ariaga & Nwanekezi, 2018; Chawla & Singh, 2015; Ogbonna, 2014; Singh & Moono, 2015; Talbert, Bonner, Mortezaei, Guregyan, Henbest & Eichler, 2020; Wang, Adesope, Sundararajan & Buckley, 2021; Wong, Sundararajan, Adesope & Nishida, 2021). Ariaga and Nwanekezi, (2018) investigated the effect of concept mapping on students' performance in organic chemistry considering the influence of gender on their performance. The study adopted a quasi-experimental design which involved a sample of 141 secondary school chemistry students in four intact class that were selected through multistage sampling technique. Performance test in organic chemistry (PTOC) was used to gather data in the study. Findings from the study disclosed that students that were exposed to concept map performed better than their counterparts in the control group. Findings further revealed that there was a significant difference in the post test scores of male and female students that were exposed to concept map in favor of the male students.

In another study, Ogbonna (2014) adopted a pretest post-test control group quasi experimental design in investigating the effect of concept mapping on students' achievement and interest in some selected concepts of organic chemistry: alkanoic acids and alkanoates. Samples of 240 senior school two (SS2) students in intact classes were selected from four out of eight secondary schools in Enugu Educational Zone which were randomly assigned experimental and control groups. Data for the study was gathered using researcher-developed concept maps, organic chemistry achievement test, and organic chemistry interest scale. The analysis of data collected

was done using descriptive statistics (mean and standard deviation) while ANCOVA was used to test the corresponding hypotheses. Findings revealed that concept mapping improved students' performance in chemistry and the difference was found to be statistically significant. An improvement in students' interest towards chemistry was also reported.

Singh and Moono (2015) conducted a study on the effect of composite use of concept maps as instructional strategy in teaching atomic structure and chemical bonding among Colleges of Education students in Zambia. The sample for the study involved 39 first year students who were divided into three groups (two experimental groups and a control group) that had 13 respondents each. Experimental group 1 was taught using concept maps and experimental group 2 were taught using the composite traditional and concept map method while the control group was taught using traditional instructional method only.

Data were gathered making use of tutor constructed chemistry achievement test and this lasted for four weeks with each group meeting three times per week. Data was analyzed using descriptive statistics (mean, mode, median and standard deviation) while one-way ANOVA was used to test the hypotheses formulated in the study. Besides, Turkey HSD test was used for post hoc analysis in instances where significant differences were recorded. Findings from the study revealed that there was no significant difference in the pretest of the three groups and this indicates that the groups were equivalent. However, there was a statistically significant difference in the post test scores of the three groups, indicating that there was improvement in the scores of students across the groups in favor of experimental group II. The authors concluded that composite use of concept map teaching strategy improved students' performance in chemistry.

In another study Chawla and Singh (2015) investigated the effect of teaching chemistry through concept mapping on the achievement of forth grade female students' in Punjab. The study

adopted a randomised pretest post-test experimental design and the sample for the study consisted of 118 female students selected from two government secondary schools (59 students randomly assigned experimental and control groups). Concept maps were utilized to teach the experimental group while the control group were taught with conventional teaching method. A mixed group intelligence test by Mehrotra (2008) was used to match the two groups into experimental and control groups respectively. While, a chemistry achievement test was employed to collect data for the study. Data gathered were analyzed using descriptive statistics (mean and standard deviation) while t-test was used to test the corresponding hypotheses. Findings indicated that there was no significant difference in the mean scores of both groups in the mixed intelligence test. On the otherhand, significant difference was reported in the achievement of experimental group and control groups in the chemistry achievement test in favour of the experimental group.

Cheema and Mirza (2013) determined the effect of concept mapping on academic performance of 7th grade students in general science. The study adopted the quasi experimental research. It involved 167 students from two single sex schools. The sample involved in the study was selected using multistage sampling that specifically utilized convenient and random sampling techniques. The convenient sampling was employed to select two single sex schools while the random sampling was used to allot the two intact classes into experimental and control groups respectively.

The instrument used for gathering data were a researcher-developed concept maps for all topics included in the material, and a science achievement test that included items from physics, chemistry and biology. Data analysis was done using ANOVA and findings revealed that significant difference existed in the performance of students in the experimental and control groups in favour of students' in the experimental group.

Talbert, Bonner, Mortezaei, Guregyan, Henbest and Eichler (2020) investigated the use of concept map in a large enrollment general chemistry course. Specifically, the study determined the implementation and assessment of concept maps among first year college level general chemistry course. The study was a quasi-experimental that was carried out in discussion group recitation sections within a third quarter chemistry course. The study comprises of two groups: an experimental group (concept map) and a control group (journal entries). An analysis of the post test scores gathered from the study using independent samples t-test revealed that students in the concept map group performed better than their counterparts in the control group.

In a more recent study, Wang, Adesope, Sundararajan and Buckley (2021) investigated the effect of different concept map activities on chemistry learning. The study determined the effectiveness of three concept map activities and adopted a quasi experimental design. The study involved undergraduate students that enrolled in an introductory chemistry course and were randomly assigned into three groups (translating concept map into paragraph format; filling in concept in a partial map and filling in labels in partial map). The content scope covered in the study was reaction enthalpy and findings revealed that the map translation group had higher achievement than their counterparts in the fill-in-concepts and fill-in labels group in conceptual understanding of reaction enthalpy when open-ended questions was used. It was further revealed that although the translation group had highest achievement as indicated by open ended questions, there was no significant difference in the conceptual understanding of reaction enthalpy among the three groups when open-ended questions was used.

In a similar study, Wong, Sundararajan, Adesope and Nishida (2021) conducted a study to determine the efficacy of using different types of concept maps. Specifically, the study investigated the effects of learning chemistry in a large undergraduate classroom, considering three concept

mapping techniques: static; fill-in-concept, and fill-in-labels. The study adopted a quasi experimental design and students were randomly assigned into three groups: reviewed a static map, completed a fill-in-concept and fill-in-labels blank spaces. Findings from the study revealed that students that were exposed to static concept maps had better achievement when compared to students in the fill-in-concept and fill-in-labels groups. It was further revealed from the findings of the study that prior knowledge was a significant predictor of students' achievement. Also, the accuracy of completing partial concept maps (fill-in-concept and fill-in-labels) mediates the influence of concept map formats on learning.

Empirical Studies on Mind Maps and Students' Achievement in Science

A Mind map is graphical tool that provides meaningful information to the learners understanding in a simple way. It prepares the mind in a way that information can be used in a logical and imaginary way to make an image in the brain (Buzan, 2000). Mind maps had been used in teaching and learning in the recent years. Okeke (2011) investigated the effect of mind mapping teaching strategy on students' achievement, interest and retention in secondary school chemistry. The study adopted a quasi-experimental, non-equivalent, non-randomized pre-test post-test control group design. A sample of 194 SSII students from Enugu Educational Zone was selected through multi stage sampling technique. The first stage involved a random selection of two local government areas from the educational zone. Secondly, purposive sampling technique was utilized to select 11 single sex schools from the two local government areas. Thirdly, stratified sampling technique was employed to select two males and two female schools from the single sex schools. Finally, the four schools were randomly assigned to experimental and control groups respectively.

The instrument used for gathering data included chemistry achievement test, a chemistry interest inventory and a retention test which also served as the achievement test. The achievement

test contained 40 questions in which 60% (25) assess the low order cognition while 40% (15) assess the higher order cognition. However, analysis was not done to ascertain students' achievement in these cognitive levels. Students in the experimental and control groups were taught with mind mapping strategy and conventional methods respectively. Data gathered were analyzed using mean and standard deviation while hypotheses that were raised in the study were tested using ANCOVA.

Findings revealed that students that were taught with mind maps had higher achievement than those taught with conventional method. The difference in their performance was found to be statistically significant. Also, the achievement of female students in post-test and retention test in the experimental group was significantly higher than their male counterparts. This finding was consistent to the assertion of Mani (2012) who conducted an expository study on the comparative effectiveness of concept mind and mind mapping strategies. The author reported that the strengths of each of these mapping strategies and concluded that both mapping strategies were capable of improving students' achievement in science. The study concluded that mind maps were intended to assist students to develop techniques for brainstorming while concept maps were intended to have a pedagogical function of presenting information and assessing learners understanding of information presented.

Gagic, Skuban, Radulovic, Stojanovic and Gajic (2019) conducted a study to investigate the efficiency of mind map on students' achievement and involvement in physics. The study utilized a pretest post-test control group design. The study involved a sample of 113 seventh- Grade students who are offering physics. Data for the study was gathered using physics knowledge test and perceived mental effort scale. ANOVA, t-test and chi-square were used to analyze the resulting data. Findings from the study revealed that teaching with mind maps had greater efficiency in

improving students' performance in physics. The study also revealed that students were more involved in the class activities during lesson while working with mind maps. The study concluded that implementing mind map for teaching physics have capacity of improving students' performance and involvement while increasing students' motivation and reducing their mental efforts.

Adodo (2013) conducted a study to determine the effect of mind mapping as a self-regulated learning strategy on students' achievement in basic science and technology. The study employed a quasi-experimental design and a sample of 120 students was involved in the study. The sample was drawn using stratified random sampling technique from two co-educational schools. Students were randomly assigned into groups that contained 30 males and 30 female students respectively. The test instrument used to gather data for the study was adopted from junior NECO past questions. Data gathered from the study was analyzed using ANCOVA and multiple classification analysis. Findings from the study revealed that students taught using mind mapping had improved performance than their counterparts in the control group. Findings also indicated that there was no significant difference in male and female students' performance when taught using mind mapping strategy.

Shodeinde (2013) determined the effect of use of mind mapping on students' achievement in abstract contents of electrical and electronic trades in technical colleges in Ogun state, Nigeria. The study utilized the quasi-experimental, pretest, post-test, non equivalent, non randomised control group design. The sample for the study consisted of 193 electrical and electronic trades year II students who were selected through the multi stage sampling technique. The first stage involved the selection of four Technical Colleges from four educational zones using the stratified sampling technique. The second stage involved ranking of these colleges from first to fourth and

were assigned to experimental (3rd and 4th) and control groups (1st and 2nd). However, the basis for the ranking was not indicated.

The instrument for data collection were electrical/electronic achievement test that contained 30 multiple choice items, two sets of researcher developed lesson plan for teaching each units for the experimental and control groups. The students in the experimental groups were guided on how to develop their own mind maps by the teacher while the control groups were taught with the conventional method. Data gathered for the study were analysed using mean and standard deviation while the formulated hypotheses were tested with ANCOVA. Findings revealed that there was a significant difference in the achievement of students in the experimental and control groups in favour of the experimental group. There was no significant difference between male and female students achievement in the experimental group.

Balin (2013) investigated the effectiveness of technology assisted concept and mind map on learning of light and sound among sixth grade primary school students. A sample of 51 respondents were involved. The study adopted a quasi experimental design with a pre test post test control group design. Three groups were involved which included two experimental groups and a control group. Students in experimental group I were exposed to technology assisted mind mapping strategy and experimental group II were taught with technology assisted concept mapping while the control group were taught using traditional classroom instruction. Data were gathered using concept test and open ended questions to gather students' opinion about the mapping strategy they were exposed to. Findings revealed that the groups' understanding of concept taught were equivalent judging from their performance. However, students exposed to technology assisted concept mapping reported positive opinion that concept maps were useful and engaging.

Akinoglu and Yasar (2007) conducted a study to determine the effect of note taking in science courses through mind mapping technique on students' attitudes, achievement and concept learning. The study adopted mixed research method that involved both quantitative and qualitative research types. In the quantitative aspect of the study, the pretest and post-test assessment model with experimental and control groups was utilised while the qualitative aspect involved document analysis. The sample for the study involved 81 students who were randomly selected from public schools in Istanbul in the scholastic year 2004-2005. The instrument for the study included; an achievement test, open ended attitude questionnaire and mind maps. Findings from the study indicated that a significant difference exist in students' concept learning, overcoming of misconceptions, academic achievement and attitude towards science courses by taking notes through the mind mapping method.

Kalyanasundaram et al., (2017) investigated the effectiveness of mind mapping technique in information retrieval among medical college students in Puducherry in India. It was a pilot study conducted using the experimental design among sixth semester Bachelor of Medicine and Bachelor of Surgery (MBBS) students in community medicine. The participants were randomly assigned into two groups. The two groups were not controlled for interaction as the treatment was training based. One group received three sided text passage of approximately 1500 words of the selected topic from a standard text book and were asked to read the topic by routine text reading method. The second group were exposed to a mind mapping session for 20 minutes to teach them about constructing mind maps. This group was asked to use mind map technique to learn the same passage with the first group. Both groups were allotted 20 minutes for the exercise and assessment was done immediately after the exercise and 7 days after. Feedback about the two methods were

obtained from the respondents. The test items used to gather data from the study assessed the lower order thinking skills only.

Data collected from the study were analyzed using SPSS version 16.0. Mean and standard deviation were used to answer the research questions while t-test and chi-square were used to test the corresponding hypotheses and content analysis was done on students' responses in the open ended questions. Results indicated that the mean gain score of the text group and mind map group immediately after the intervention were not statistically significant. The scores of the two groups at 7 days after the intervention revealed that the mind map group achievement were significantly higher than that of the text group. Before the intervention, the text group had a lower mean score than the mind map group but the difference was not statistically significant. Also students rating of the two teaching methods in parameters such as easy understanding of the topic, objectives achieved, significantly high proportion of the mind map groups gave very good and excellent rating to the method when compared to the text groups.

Parikh (2016) investigated the effectiveness of teaching with mind mapping technique on students' accomplishments in 8th class social science subject. The study specifically sought the effectiveness of mind map on teaching resources for creating the program usage. Students' opinion on the effectiveness of mind maps was also investigated. The study involved 120 students in 2014/2015 academic year in Ghandhinagar district.

The sample for the study involved two groups of boys and two groups of girls who were assigned into experimental and control groups for both genders. The experimental groups (male and female) were taught with mind maps while the control group (male and female) were taught with conventional method. After treatment, copies of a questionnaire was made available to the

students to elicit their opinions on the effectiveness of mind maps in teaching/learning. Data gathered from the study were analysed using t-test and Chi-square statistics.

Findings from the study revealed that the mind map group had better achievement than the control group. There was no significant difference in the achievement of the experimental groups (male and female) and control groups (male and female). However, there was a significant difference in the male and female students achievement in the experimental and control groups. Analysis of students' opinion revealed that students taught with mind maps had positive opinion towards its use. This finding corroborates the findings of Yunus and Chien, (2016) who noted that pre university students had positive perceptions on the use of mindmapping strategy in their writing skills when they investigated students perception on the use of mind mapping in Malaysian University English Test (MUET) writing. The study employed a descriptive research of the survey type that involved a sample of 25 respondents from six (pre university students). The instrument utilized in the study was adapted from Goodnough and Woods (2002) that contained seven close ended questions. Data gathered from the study was analysed using frequency counts and percentages.

Singh and Kaur, (2004) investigated the effects of mapping strategies and brainstorming strategies in developing mental capacities in writing skills of selected form III students. The study adopted a non randomised control group pretest posttest quasi experimental design. The sample of respondents involved 50 students in their form II final examination year. A pretest and post-test composition question, direct observations and indepth interview were used to gather data for the study. Data collected was analysed using SPSS for percentages, mean, SD, t-test, repeated measures ANOVA. Findings from the study revealed that there was a significant difference in the mean score of students in the experimental and control groups. Findings also showed that

respondents in the experimental group responded positively to the mind map and brainstorming strategy.

Studies on Students' Perception on the use of Graphic Organizers in Teaching and Learning

Students' perception is regarded as one of the attributes that influences learning. It determines the level of attention that learners place on the content of instruction and thus influences their achievement. Entwistle, McCune and Hounsell (2002) opined that students' perception of teaching and instructional materials influences their learning more than the teaching method thus, influences the cognitive effort they put in learning. Studies have reported that perception of students of their learning environment and classroom experience significantly influences learning (NeSmith, 2003). Therefore, when students are provided with learning environments that enhance positive perception towards learning, then, teaching and learning is improved (Lucas, 2001)

Studies have been conducted to investigate students' perception on graphic organizers in learning science (Aydin, 2015; Goodnough & Woods, 2002). Goodnough and Woods (2002) conducted an interpretative case study research on students and teachers' perceptions of mind mapping among sixth –grade students in science. A sample of 15 students were involved in the study and data was gathered using a semi structured interview, observation and Questionnaire. Data was analyzed thematically ranging from assigning tags to short tags to text to broader themes. Findings from the study revealed that students perceived mind maps as an interesting and motivating approach and as such improves learning. It was also reported that students conceptualize mind maps as having variety of purposes in learning science.

Aydin (2015) investigated the effect of technology support mind map and concept map on students' learning of science concept. The study determined students' opinions when studying by preparing concept maps and mind maps as well as the practices that was involved. The study

adopted a quasi-experimental design which involved a sample of 62 respondents that studied “systems in our body” unit. Findings from the study indicated that students taught with technology support mind map and concept map had a better comprehension than their counterparts in the control group and that the mapping strategies were fun and instructive. Findings further revealed that students in the technology supported mind map group had better achievement than their colleagues in the concept map group. It was therefore recommended in the study that should consider the use of either of these mapping strategies to reveal prior knowledge so that students can make necessary connections within their cognitive structures to enhance learning.

Lok (2014) conducted a study on the effect of concept mapping in learning physical chemistry among college students of Perak Matriculation College. The study specifically investigated the attitude and perceptions of students towards the use of concept mapping as a learning tool in physical chemistry. The study adopted a mixed method research approach that involved the use of quantitative and qualitative data. The sample for the study involved 57 participants that were exposed to concept mapping. Findings revealed that participants agreed concept mapping help them in integrating and making clarifications about interrelationships between the concepts on the maps. Findings from the qualitative aspect of the study revealed that students perceived that concept map helped them to summarize their learning material. However, they reported difficulties in constructing their own maps and that time was a significant factor in working with concept maps and was not sure if it was really helpful. Findings further revealed that respondents are of the opinion that concept mapping is a good tool in chemistry but may be difficult to adapt for other subjects with more concepts.

Langford (2014) investigated the use of concept mapping in enhancing teaching of chemical equilibrium among grade 12 physical science students. The study employed a qualitative

research design which is phenomenological in nature. The study utilized convenience sampling technique to select five learners that participated in the study. Data were gathered using the concept map and follow up interviews. Data was analyzed using the assessment rubric that was developed for the study. Findings revealed that concept maps positively influenced students' understanding of chemical equilibrium and improved students' participation during class. In another study by Rahmad (2019) explored students' perception on the use of mind map in learning writing. The study utilized a mixed method design to specifically find out the advantages and disadvantages of leaning writing using mind maps. A total of 23 students that used mind mapping application for learning writing were purposively selected for the study. Questionnaire and interview were used to gather data for the study. Findings from the study revealed that mind map application helped students to develop, remember and organize their ideas. Findings further revealed that respondents identified disadvantages of using the maps such as taking longer time to finish writing and that the mind map application required computer access and as such made the process complicated.

Ravindranath, Abrew and Nadarajah (2016) conducted a study to determine whether problem based learning experience can be enhanced through the use of mind map for writing summary. The study involved 813 semester 2 medical students who had prior experience about problem based learning. Data was gathered using a 10 items questionnaire that was entitled perception of students on the use of mind maps. Data was analyzed using mean and standard deviation while the responses from interview were put into themes. Findings from the study revealed that students held positive perception towards using mind mapping and some of the respondents demonstrated clear hierarchical organization and interrelation of topics using links between branches. Findings from the interview further revealed that responses were grouped into

five themes of problem learning processes, time consuming activity, mind mapping skills, helps in revision and attitude towards mind mapping in problem based learning.

Yunus and Chien (2016) in a study on students' perception on the use of mind mapping in Malaysian University English Test (MUET) writing reported that students perceived mind maps as an easy to implement tool in learning. The study adopted a survey research in which both quantitative and qualitative data were gathered simultaneously. The instrument used in the study was adapted from the work of Goodnough and Woods (2002) and was administered to 25 respondents that formed the sample for the study. However, it was noted that the mind maps was utilized during teaching as against using it as an advance organizer in the present study.

Trehan (2015) determined the impact of concept mapping on students' perception of and experiences with introductory statistics. The study adopted a qualitative case study approach which involved 12 respondents that were selected through convenience sampling technique. Students were exposed to concept mapping as a learning tool and their perception towards using it were sought using use of semi-structured interview and questionnaire. Findings from the study showed that participants showed mixed reactions towards using concept mapping as a learning tool even after they have reported that concept maps positively influenced their understanding of statistical concepts. Findings further revealed that respondents reported perceived difficulties in working with the concept maps. Such difficulties include; making connections between concepts, time consuming among others.

Empirical Studies on Innovative Strategies and Students' Achievement in Organic Chemistry

Organic chemistry is a sub-discipline in chemistry that focuses on the study of compounds containing carbon and hydrogen and may as well contain any other element(s). Over the years,

students' performance in organic aspect of chemistry has been recorded to be low. Several studies have been conducted to improve students' achievement in organic chemistry. For instance, Supasorn, Kamsai and Promarak (2014) investigated students' achievement and retention in organic chemistry using inquiry- based Semi- Small Scale Experiments (SSSE) among High School students. The study also determined students' satisfaction as regards the use of inquiry-based SSSE.

The scope of organic chemistry examined in the study include; functional groups, hydrocarbons, alcohol and ethers, aldehydes and ketones, carboxylic acids, esters , amines and amides. The SSSE experiments was conducted based on the 5E learning cycle. The instrument utilised in the study were developed inquiry- based SSSE for organic chemistry, achievement test for organic chemistry and questionnaire on students' satisfaction towards the inquiry- based SSSE in organic chemistry.

Data gathered were analysed using descriptive statistics of the mean and standard deviation while t-test was used to test the hypotheses generated. Findings indicated that students recorded better performance when taught with inquiry- based SSSE. Their retention was also promoted as there was no significant difference in the post-test and retention test of the respondents. The students indicated a high level of satisfaction in learning organic chemistry using the inquiry-based SSSE. This finding is in agreement with those of Ogbonna (2014) who reported that concept mapping instructional strategy improved students achievement in organic chemistry (alkanols and alkanoates) and also a statistically significant effect was reported on students' interest in learning organic chemistry.

De-Gale and Boisselle (2015) conducted an action reasearch that studied the effect of Process Oriented Guided Inquiry Learning (POGIL) on students' performance and confidence in

organic chemistry. The study was carried out within an in-service teacher education programme and the content of organic chemistry taught were carbon compounds and homologous series, nomenclature of organic compounds, isomerism, movement of electrons in organic molecules and type of reagents, hybridisation and physical properties of alkanes and alkenes, reactions of alkanes and alkenes, naming of alcohols and reactions of alcohols. The study adopted the quasi experimental design because the sample involved were not randomised. Only one group was involved in the study which indicated that there was never a control group on the basis to which the effect of the treatment can be compared.

To ascertain students' performance at the end of the treatment, a post test only design was employed. Since there was no control group, students' performance was compared with their end-of-term score in previous end of the term examination. A pre test and post test design was adopted to find out the effect of POGIL on the academic confidence of the students' in organic chemistry. Descriptive statistics (mean and standard deviation) and inferential statistics (t-test) was used to analyse data that were gathered for the study. Findings from the study indicated that students showed a decrease in overall mean score with the respondents showing varying degree of academic performance. In addition, there was an increase in students' confidence after been taught with POGIL.

Okereke (2011) investigated the influence of gender, school location and play-simulation on students' achievement in organic chemistry in Owerri Education Zone, Imo State. The study was a pre test post test quasi experimental design. The study considered gender and school location as moderator variables. The study involved four intact SS one classes that were purposively selected based on gender and location. Research instrument utilised in the study was a lesson plan and a 45 minutes DVD recorded play that personified organic substance and acted their properties,

uses and consequences as abusing them. A chemistry achievement test that contained 40 objective questions was used to gather data for the study. Data was analysed using mean, standard deviation and ANCOVA. Findings revealed that male students had improved performance than the female students when taught organic chemistry using the play simulation method and the difference in their performance was statistically significant. Also, students in urban school achieved better than students in rural schools and the difference was found to be statistically significant.

Studies on Cognitive Style and Academic Achievement of Students' in Science

Cognitive style is referred to the way an individual prefers to process information. Khandagale (2016) described it as the way an individual filters information, process stimuli and conceptually organize the environment so that the environment can take on psychological meaning. It describes the way of constructing knowledge of an individual and personality dimensions. Jonassen and Grabowski (1993) termed cognitive style as a global term that refers to the way individuals see and interact with the world around them. Cognitive styles are of various types these includes; visual/verbalizer, visual/ hepatic; leveling / sharpening; serialist/ holist; wholistic/ analytic; field dependent/ field independent. However, the present study will categorize cognitive style in terms of field dependent and field independent because this category is the most widely used in literature (DeTrue, 2004). This is based on the ability of individuals to distinguish and separate elements from complex settings.

Field independent individuals are characterized by their ability to abstract an element from its context, that is learners in this category approach problem solving in an analytic manner. However, the field dependent individuals approach problem solving in a global way. They are characterised by their ability to recall information (Altun & Cakan, 2006). Several studies had been conducted to investigate the influence of cognitive styles on students' academic achievement

(Altun & Cakan, 2006; Ramlah, 2014; Ella, 2014; Onyekuru, 2015; Sara, Maruta & Olarinoye; 2016).

Ella (2014) conducted a correlational survey research to determine the cognitive styles and attitude towards science of senior secondary school science students of high and low cognitive abilities. The population for the study consisted of 1330 students that were selected through proportionate stratified random sampling technique. The research instruments were GEFT, science students' attitude scale and science cognitive ability levels. Data gathered were analysed using mean and standard deviation while corresponding hypotheses were tested using t-test and regression analysis. Findings from the study revealed that high cognitive ability students showed positive attitude to science and belonged to field independent category than the low cognitive ability students.

Bassey, Umoren and Udida (2013) explored the influence of cognitive styles and attitude of senior secondary school students on their academic performance in chemistry in Akwa Ibom, Nigeria. The study employed an ex post facto research design which involved 400 SS3 students who were randomly selected. The research instrument was a Siegel's cognitive style test, chemistry attitude test and a chemistry achievement test. The cognitive style test contained 20 familiar pictures in threes that required the students to match two similar pictures and provide justification for their choice.

The test classified the respondents into analytic, relational and inferential based on the reason suggested. Analysis of variance (ANOVA), Person Product Moment Correlation were used to analyse the data gathered in the study. Findings from the study revealed that respondents in the analytic category had the highest mean score while respondents in the relational category had the least mean score. Also, significant difference was reported on students' academic performance

based on their cognitive styles in favour of the analytic cognitive styles. A significant positive relationship between students attitude towards chemistry and their performance was further reported.

Idika (2017) conducted a survey research on influence of cognitive style and gender on secondary school students' achievement in and attitude to chemistry. The study involved 208 SSII chemistry students selected from six secondary schools in three local government areas in Ibadan, Nigeria. A cognitive style checklist, chemistry achievement test and students' attitude to chemistry questionnaire were used to collect data for the study. The cognitive style checklist utilized in the study was adapted from the work of Wyss (2002).

The instrument contained ten (10) simple statements divided into two sub statements A and B. The respondents are to choose the response that applies to them i.e either A or B. respondents were categorised as field independent if they choose up to seven As and above while respondents that choose between six As and below were categorised as field dependent. The questionnaire and the checklist were administered on the same day while the test was administered a day after. Data were analysed using mean and standard deviation while corresponding hypotheses weretested using t-test statistics. The research instrumentof this study is in contrast to earlier studies reviewed because the instrument is different from the GEFT and Siegel's cognitive style test that was utilised in other researches whose components are figures rather than statements.

Findings from the study disclosed that significant difference existed in the performance of field dependent and field independent cognitive styles in favour of the field independent students. Reports indicated that there was no significant difference in the achievement of male and female students in chemistry. It was also reported that there was no significant difference in the attitude of field dependent and field independent students towards chemistry.

Musya (2015) investigated the extent to which cognitive style of secondary school students' influenced their academic performance in chemistry in Kenya. Specifically, the study determined the various types of cognitive styles exhibited among the respondents. It further, investigated the differences in cognitive styles of male and female respondents as well as the relationship between cognitive styles and students' academic achievement in chemistry. The respondents were selected through stratified and systematic random sampling. The instrument utilized was a questionnaire that elicited information about the respondents' biodata, cognitive style and their academic achievement from two chemistry test they did before the study. The cognitive style section of the instrument was adopted from the works of Wyss (2002). Data analysis were carried out by computing the mean and standard deviation of their scores in chemistry and PPMC was used to compute the correlation coefficient.

Findings from the study indicated that the respondents were in the field dependent and field independent categories. Also, higher percentage of the male students were found to be field dependent while higher percentage of female students were found to be field independent. Furthermore, the field independent students recorded higher achievement than students in the field dependent category. The study therefore concluded that students' cognitive style influenced their performance in chemistry and that there are differences in male and female chemistry students' cognitive styles. The findings from this study was in contrast to those of Ramlah (2014) who reported that female students tends to belong to field dependent cognitive styles while the male students are associated with field independent cognitive styles.

Sara, Maruta and Olarinoye (2016) investigated the relationships between cognitive styles and senior secondary school students' achievement in science process skills in Jigawa. The study adopted a correlational survey design and involved 216 respondents who were selected using

proportionate sampling technique. GEFT and biology science process skills achievement test were used as research instrument for the study. Respondents' cognitive style were categorised into three; field dependent, field independent and field neutral. Data was analysed using t-test and Pearson's Product Moment Correlation statistics. Findings revealed that cognitive styles are related to students' achievement in biology process skills. Specifically, strong positive correlation was reported between field dependency cognitive style and students' achievement in science process skills. However, a moderate positive correlation was reported between field independency and students' achievement in science process skills while a moderate correlation was also reported for field neutral cognitive style and students' achievement in science process skills.

Kuldeep and Meera (2016), conducted a study on the cognitive styles of science teachers in India to determine the differences between male and female secondary school teachers based on five cognitive styles (systematic, intuitive, integrated, undifferentiated and split cognitive styles). The research adopted a survey method and utilized cognitive style inventory developed by Praveen (2001) as research instrument. Data was analysed using descriptive statistics of mean and standard deviation, while t-test was used to test the hypotheses raised in the study. Findings revealed a significant difference in male and female teachers' cognitive styles in systematic (favouring male) and intuitive (favouring females) cognitive styles. However, no significant difference was observed in integrated, undifferentiated and split cognitive style between male and female teachers.

Onyekuru (2015) investigated the relationship among field dependent and field independent cognitive styles with students gender, career choice and academic achievement. A sample of 320 respondents (science and arts students) were selected using simple random sampling technique in which 68 were field independent, 90 were field dependent. Students who were neither field

dependent nor field independent (ambiverts) were 162 and these were excluded from the final data that was analysed in the study.

The researcher categorised students into field dependent and field independent when they scored less than or equal to the difference between the mean and the standard deviation and when they score greater than or equal to the sum of the mean and the standard deviation in the GEFT respectively. Data analysis was carried out using t-test and chi-square. Results revealed that significant difference existed in the achievement of field dependent and field independent students in science and arts students respectively. The field independent students were reported to have a higher mean score in sciences than the field dependent while the field dependent had a higher mean score than the field independent in arts. Using chi-square statistics, a significant relationship was found to exist between students' cognitive style and gender. Furthermore, there was a significant relationship between students' cognitive style and their career choice.

Similarly, Altun and Cakan (2006) utilized the GEFT in a study that investigated a sample of 130 preservice teachers and their attitude towards computer. A computer attitude questionnaire was also utilized as research instrument in the study. The computer attitude questionnaire was administered at a week interval after the GEFT had been administered. Correlation analysis and ANCOVA were used to analyse the data gathered and findings indicated that there was no significant correlation between students' academic achievement and their cognitive styles. This findings did not support those of other studies reviewed which reported a positive correlation between students' field independent cognitive styles and their academic achievement in sciences. In addition, findings from the study revealed that students' attitude towards computer is independent of their cognitive style.

Ogan (2012) explored the influence of cognitive style on selected areas of mathematics in Ogoja, Cross Rivers State. The study was an ex post facto type that involved 620 SS2 mathematics students who were selected using multi stage sampling technique. Simple random sampling technique was first utilized to select three out of five local governments in the educational zone after which purposive sampling technique was used to select thirteen (13) co-educational schools from the three schools. The sample for the study involved all SS2 students in the selected schools. The instrument for data collection was the GEFT and a mathematics achievement test. The GEFT was not validated because it was a standardised instrument. However, the mathematics achievement test was validated and its reliability was determined using Kuder Richardson formula 20 (KR-20).

The respondents in the study were categorised into field dependent and field independent cognitive styles while the data gathered were analysed using mean, standard deviation and t-test statistics. Findings from the study disclosed that field independent students were higher achievers than the field dependent students in mathematics. Results from testing the corresponding hypotheses revealed that there was a significant difference in mean achievement score of field dependent and field independent students in favour of the field independent students. Furthermore, a significant difference was also reported in the mean achievement score of male and female students in geometry in favour of the female students. Findings also indicated that there was no significant difference in male and female students achievement score in algebra and statistics. This study is related to the present study since the present study investigated the influence of cognitive style on students' achievement in organic chemistry using the GEFT.

Suderman, Setyosari, Kuswandi and Dwiyoogo (2016) probed into the effect learning strategies (problem based learning and hands on learning strategy) and cognitive styles toward

mathematical problem solving learning outcomes among grade five pupils in Indonesia. The study utilized the 2x2 quasi experimental design and multistage sampling technique was adopted to select the subjects in the study. Two research instruments were employed to gather data in the study (GEFT and problem solving ability test). Data were analysed using descriptive statistics of mean and standard deviation while ANOVA was utilized to test the corresponding hypotheses. Findings from the study pointed out that students in the problem based learning group performed better than the hands-on learning strategy group and the difference was statistically significant. In addition, the field independent learners performed significantly better than the field dependent learners and a significant interaction effect was recorded towards the learning strategies, cognitive style and problem solving outcomes.

It can be deduced from earlier studies that researchers utilized various types of instruments to measure cognitive styles of students apart from the GEFT. However, the present study will utilize the commonly used instrument (GEFT) to obtain data on the cognitive styles of the respondents. Students will be categorised into two groups which are, field- dependent and field-independent. The choice of the GEFT over other cognitive style instrument is because it is a non verbal test that deals with learners' cognitive ability and not related to any subject matter in the school curriculum.

Studies on Influence of Gender on Students' Achievement in Chemistry

Gender is referred as the biological state of existing as either a male or a female. It can be regarded as a socio cultural construct that differentiates the role, behavior, emotional and mental characteristics between male and female (Udosoro, 2011). It is termed a psychological description of behavior and attributes expected of individuals by existing as either a male or a female (Umoh,

2003). However, students' gender has been reported to have influence on their performance in chemistry (Adesoji & Kenni, 2013).

Gongden and Delmang (2016) investigated the efficacy of concept mapping instructional strategy and influence of gender in remediating difficulties that students experience in stoichiometry. The study adopted a pretest post-test control group design. A sample of 60 students were randomly selected for the study. Data was gathered using stoichiometry problem solving test (SPST) which was an open ended test that contained 3 items. *T*-test statistics was used to test the hypotheses that was raised in the study and findings showed that students taught with concept mapping had improved efficacy than their counterparts in the control group. Findings further revealed that there was no significant difference between the performance of male and female students. The study therefore concluded that concept mapping can enhance student's performance in stoichiometry problem-solving and this is achievable irrespective of students' gender.

Aniodoh and Egbo (2013) conducted a pretest post-test non equivalent control group quasi experimental study to determine the effect of gender on students' achievement in chemistry using inquiry role instructional model in Enugu, Nigeria. The study involved SS2 intact classes in four single sex schools that were purposively selected for the study. The scope of the study was limited to qualitative analysis which covered preliminary test for cations and anions. Two males and two female schools were randomly assigned the experimental and control groups respectively. Mean and standard deviation were used to analyze the data gathered while ANCOVA was used to test the null hypotheses that were formulated.

Findings from the study revealed that inquiry role model was found to be more effective than the conventional teaching method. Female chemistry students had better achievement than their male counterparts even though the difference was not found to be statistically significant.

These findings are at variance with those of Okereke (2011) which involved the use of play-simulation and which reported that male students performed significantly better than the female students in chemistry. Although, the content scope of the study was limited to organic chemistry and school location was considered as a variable in the study.

Popoola and Olorundare (2017) conducted a study involving the use of problem based instructional strategy (PBIS) on chemistry students' performance in gas laws. The study employed a pretest post-test non randomised and non equivalent quasi experimental design . Two intact classes that was assigned to experimental and control groups were purposively selected for the study and data were gathered using a problem based instructional material designed by the researchers as well as a chemistry achievement test on gas laws. Data gathered was analysed using t-test and findings revealed that there was no significant difference in the performance of male and female students when taught gas laws using PBIS. This finding is similar to those of Keter, Wachanga, and Anditi (2016) who reported no significant difference in the mean gain score of male and female students motivation to learn chemistry in a study which investigated the effect of gender on motivation in chemistry lesson when students were exposed to computer based cooperative mastery learning approach in Kenya. The study utilized Solomon four non-equivalent control group design involving a sample of 238 respondents that were purposively selected. The study involved two experimental and two control groups while a student motivation questionnaire was used as research instrument for the study. Mean and standard deviation were used to answer research questions while t-test was used to test the hypotheses.

Ezendu and Obi (2013) investigated the effect of gender and school location on students' achievement in chemistry in secondary schools in Enugu State, Nigeria. The study was an ex-post facto type and the study covered 827 students who were randomly selected from eight co

educational schools in Nsukka, Nigeria. A proforma that elicited students' grade in WASSCE chemistry examination between 2009 to 2012 was used as research instrument. Data gathered were analysed using mean and standard deviation while t-test was used to test the corresponding hypotheses. Findings revealed that there was a statistically significant difference in mean achievement of male and female students in chemistry in favor of male students. This finding however contradicts those of Idika (2017) who reported no statistically significant difference in the achievement of male and female students taught chemistry.

Chawla (2015) investigated the effectiveness of concept mapping on the achievement of fourth graders in chemistry. The study involved 236 students that were randomly selected from four schools. Two groups were assigned experimental and control respectively. The instrument utilised in the study were mixed group intelligence test by Mehrotra (2008), developed concept maps and a chemistry achievement test. The experimental and control groups were matched with the test of intelligence to ensure equivalence. Findings from the study revealed that the experimental group performed significantly better than the control group. It was further revealed that the mean gain score was higher for the male students than their female counterparts. However, the difference was not found to be statistically significant. This finding is in contrast to those of Ogbonna (2014) who reported that a statistically significant difference exists in the achievement of male and female students' towards chemistry in favor of the male students when they were taught using concept mapping instructional strategy.

Eya and Ezech (2020) conducted a meta-analysis of influence of gender on students' academic achievement in chemistry. The study involved 62 researches from previous studies and two research questions and one hypothesis was raised to guide the study. A meta-analytic research design was used in this study and purposive sampling was used to select the research analysed in

the study. The studies selected were those conducted between 1990 to 2017 and percentages, statistical transformations and winer combined test was used for data analysis. Findings revealed that gender has small effect on students' achievement in chemistry and the percentage variance in their academic achievement attributed to gender is 3.8% and this figure is considered to be low.

Appraisal of the Reviewed Literature

The literature reviewed showed evidence of related studies to the present study. Such studies include: Akinbobola (2015); Bamidele, Adeniyi, Awodele and Irinoye (2013); Ekenobi and Mumuni (2015); Oloyede (2011); Torres, Espana and Orleans (2014); Wachanga, Arimba and Mbugua, (2013). Bamidele, Adeniyi, Awodele and Irinoye (2013) explored the use of hierachial, flow charts and spider maps on students' attitude in mole, stoichiometry, gas laws, calculations involving gas volumes, solubility and electrolysis. Their study is related to the present study as it explored the use of charts and maps which are types of graphic organizer. The study however differs in that the present study will explore the use of mind map and concept maps rather than hierachial, flow charts and spider maps as graphic organizers. Mixed method design will be adopted for the present study as against the quasi experimental design utilised in their study. This is because this design is found to be most appropriate as it will provide more insight into the effect of the organizer through the use of qualitative data.

Ekenobi and Mumuni (2015) investigated the self efficacy on students' achievement in redox reaction concepts in Rivers state comparing graphic and textual organizers. Their study considered cognitive achievement (high and low order levels of the Blooms' taxonomy) and gender as variables as in the present study. The present study will however, considered influence of cognitive styles on students' achievement in hydrocarbons rather than the topic of redox

reactions. This is because hydrocarbons had been identified as one of the topics students perceived to be difficult in chemistry.

Oloyede (2011) investigated comparative effect of pictorial and written advance organizers in the concept of energy change in chemistry in Bauchi as contrary to concept and mind map as graphic organizer that will be compared in the present study . The study, considered gender and retention as variables as against cognitive style and gender which the present study explored. In the study of Torres, Espana and Orleans (2014), the attitude of freshmen students in chemistry using venn diagrams, flow charts and pictorial forms as graphic organizers were examined. Besides, they utilised a mixed research method which is synonymous to what was utilised in the present study. The present study will investigate influence of gender and cognitive styles of the respondents on their achievement in organic chemistry. This is due to the fact that these variables had been reported to influence students' achievement in chemistry.

Wachanga, Arimba and Mbugua (2013) investigated the effectiveness of graphic organizers in form of charts in representing facts and concepts on students achievement in the mole concept. Specifically, the study investigated the mole, calculations involving the relative and molecular masses of chemical compounds. Whereas in the present study, organic chemistry is being investigated. The research was conducted in Kenya and Solomon four design was adopted in the study. The present study was conducted in Ilorin, Nigeria and a mixed method research design was adopted. It was believed that using this method would provide both quantitative and qualitative data which would further provide more insight into the effect of graphic organizers on students' achievement in organic chemistry.

Studies related to gender and students achievement in chemistry were reviewed from Aniodoh and Egbo (2013); Ezendu and Obi (2013); Okereke (2011); Popoola and Olorundare

(2017). Popoola and Olorundare (2017) as well as Aniodoh and Egbo (2013) reported no significant difference in the performance of male and female students in chemistry. Ezendu and Obi (2013) and Okereke (2011) reported that male students had improved performance than the female students in chemistry and the difference in their performance was found to be statistically significant. Inconsistencies in findings related to students' gender and their achievement in chemistry influenced the current study in investigating the influence of gender on students' achievement in chemistry when they were taught with graphic organizers. There was no report on the influence of cognitive styles of students when taught with graphic organizer in earlier studies. Consequently, the present study investigated the influence of cognitive style as a variable on the achievement of students in hydrocarbons having identified in literature that cognitive style influences students' achievement. Besides, the present study utilised the GEFT developed by Witkin, Oltman, Raskin and Karp (1971) in their study as against Siegel's cognitive style test and cognitive style checklist developed by Wyss (2002) in categorizing students into cognitive styles. This choice is influenced by the fact that the GEFT is a non-verbal test instrument that is not subject-specific whose validity has been reported over the years.

CHAPTER THREE

METHODOLOGY

This chapter describes the method that was used in carrying out this study. It has been discussed under the following subheadings; Research Design, Population, Sample and Sampling Techniques, Research Instrument, Validation of Research Instrument, Procedure for Data Collection and Data Analysis Techniques.

Research Design

The study adopted an explanatory- sequential mixed method design. Specifically, the design is multiple case research design which involved triangulation of the data convergence model. This design was considered appropriate because it enabled the researcher to implement quantitative and qualitative methods at the same time frame. It was used to obtain different but complementary data on the research problem to best provide answer to it. The quantitative and qualitative data were gathered at different phases during the research. Table 6 shows the summary of the mixed method procedure that was utilized and the type of data that were gathered at the various phases of the research.

Table 6
Summary of Research Design

Stages	Phase	Procedure	Product
I	Quantitative data collection	Test outcome and questionnaire	Numeric data
II	Quantitative data analysis	Using descriptive and inferential statistics	Meaningful measures
III	Connecting quantitative and qualitative data	Focus group interview (purposive selection of respondents and development of interview questions)	Interview protocol
IV	Qualitative data collection	In-depth interview	Textual data
V	Qualitative data analysis	Coding and thematic analysis	Codes and themes that are similar and different
VI	Integration of quantitative and qualitative results	Interpretation and explanation of quantitative and qualitative results	Discussion and implication for future research

The quantitative aspect of the study involved a quasi-experimental and a survey research. The quasi experimental aspect of the study involved a 3x2x2 pretest, post-test, non- equivalent and non-randomized control group design. The 3 represents three groups (two treatment groups and one control group), 2 represents cognitive style at two levels (field dependent and field independent) and gender at two levels (male and female). The experimental groups I and II were taught using concept map and mind map organizers respectively, while the conventional teaching method was used to teach the control group. Each of the three groups will be exposed to a pre-test and post-test before and after being exposed to treatment respectively. The survey part of the quantitative data was gathered by adopting the use of questionnaire. This was considered

appropriate as it allowed the researcher to seek and determine the perception of the respondents in the two experimental groups on the effectiveness of the treatment they were exposed.

The qualitative aspect of this study was phenomenological in nature as it provided opportunity for the researcher to understand the experiences of the respondents after being exposed to the graphic organizer (phenomenon) in their various groups. Qualitative data was gathered through the use of a semi structured interview format to elicit the views of respondents focusing on respondents in the field dependent and field independent categories. This was deemed to be appropriate because it assisted the researcher to obtain detailed responses from the respondents about their experience when taught with the different instructional strategies. Such responses could be restricted if a survey method was used. Figure 2 shows a description of the research design framework.

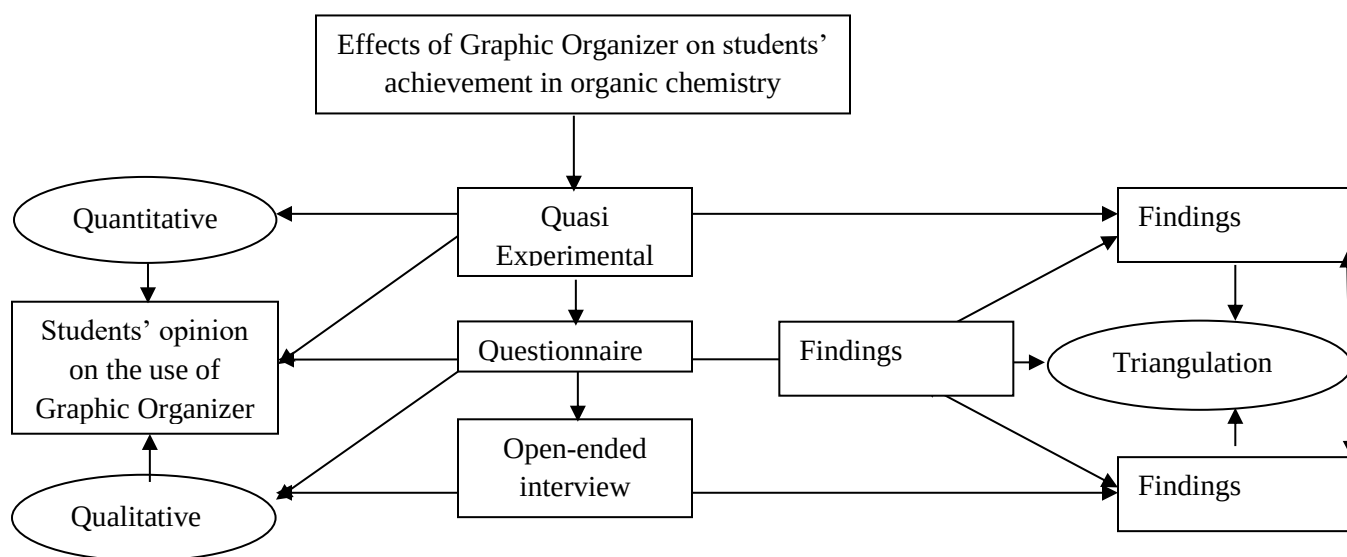


Figure 2: Research design framework

Population, Sample and Sampling Techniques

The population for this study was all senior secondary school students offering chemistry in Ilorin metropolis. The target population was all SS2 students in chemistry classes. Three intact

classes were selected from three schools that were purposively selected within the metropolis. A total of 183 students from the selected classes served as the sample for the study. The criteria for selecting the schools included:

1. Must be owned by the government and as such, utilize the same admission requirement as prescribed by the state government.
2. Must be coeducational and established about the same period of time at least not less than 10 years old.
3. Must have presented students external examinations for at least five consecutive years.

Research Instrument

Seven research instruments were utilized to collect data for this study. They included: a researcher-developed concept map graphic organizer, mind map graphic organizer, four lesson plans for each group (two experimental and a control group) and an organic chemistry achievement test was used as a pretest and post-test after the items were re-scrambled. In addition, two questionnaires entitled Questionnaire on Students Perception on the use of Concept Map Graphic Organizer (SPCM) and Questionnaire on Students Perception on the use of Mind Map Graphic Organizer (SPMM) were adapted from the work of Goodnough and Woods (2002), Group Embedded Figure Test (GEFT) adopted from Witkin, Oltman, Raskin and Karp (2003) and an interview protocol. The precedings are shown in Appendices I to VIII

The researcher-developed concept map graphic organizer and mind map graphic organizer were developed. The concept maps were developed to contain the content of instruction and prerequisite knowledge that are related to hydrocarbons. The concept maps contained linking words and show relationships among the various concepts in hydrocarbon. However, the mind map advance organizer was also developed to contain the content of instruction and prerequisite

knowledge that are related to the content of instruction. This map lacks linking words and each of the concept is written in coloured boxes as opposed to the concept maps advance organizer.

Four lesson plans were prepared for each of the groups (two experimental and a control) by the researcher to teach hydrocarbons. The first and second lesson plans were developed to teach the general concepts in hydrocarbon and nomenclature, isomerism in organic compounds for 40 minutes respectively. The third and fourth lesson plans were developed for periods of 80 minutes each. Each of the lesson plans was developed to teach chemistry of alkanes and alkenes; and the chemistry of alkynes and aromatic hydrocarbons respectively.

The organic chemistry achievement test items were adapted from past WASSCE chemistry examination questions. They are drawn based on the revised Bloom's taxonomy to ensure it assess students' achievement in both high and low order cognitive levels. The test contained 50 multiple choice items which lasted for 45 minutes. Also, GEFT developed by Witkin, Oltman, Raskin and Karp (1971) and revised in 2003 was adopted in categorizing students into cognitive styles (field dependent and field independent). The cognitive style instrument contains non-verbal test items in form of figures which included a section for demographic characteristics of the respondents. The verbal test items in the GEFT contained a sample test item that guided the respondents on how to attempt other test items. The GEFT was further divided into three sections (3) titled section one, section two and section three where each of these sections contains 7, 8, and 9 complex figures respectively. Finally, the GEFT contains in its last page, 8 simple forms labeled A to H that students were expected to trace in the complex figures in sections one, two and three respectively.

Two questionnaires (SPCM and SPMM) adapted from the works of Goodnough and Woods (2001) were employed to determine perception of the respondents on the use of concept map graphic organizer and mind map organizers respectively. The questionnaires contain two

sections A and B. Section A elicited demographic information of the respondents such as gender, school name and class level. Section B contained 18 items in two constructs that sought respondents' view on the use of the organizers they were exposed to. In addition, a semi-structured interview protocol was developed to elicit students' responses on the effect of the organizer they were exposed to. The interview protocol was developed using guidelines of Interview Protocol Refinement (IPR) framework by Castillo-Montoya (2016). The protocol contains four closed ended interview questions and five follow-up questions. Responses were coded and categorized into various themes as shown in Appendix VIII.

Validation of Research Instrument

The mind map and concept map graphic organizers were validated by two experienced chemistry teachers in senior secondary schools and a lecturer in Department of Educational Technology, University of Ilorin. The lesson plans were validated by three lecturers in the Department of Science Education, University of Ilorin and two experienced senior secondary school chemistry teachers. Furthermore, the questionnaires and interview protocol were given to two other lecturers in the Department of Science Education, University of Ilorin to determine their face and content validities. A table of specification was used as a guide in developing the test items to ensure that a high percentage of levels of the cognitive process skills were represented in line with the revised Bloom's taxonomy.

Item analysis was carried out on the items in the achievement test to improve the quality of the items. This is because the test items were adapted from previous senior school certificate chemistry examinations. The final draft of the instruments was scrutinized by the researcher's supervisor for further suggestions. The GEFT was already a standardized instrument that was adopted hence was not re-validated in this study since its reliability had been earlier established.

The reliability of the achievement test was carried out using the test retest method and Pearson's Product Moment Correlation was used to calculate the reliability coefficient that yielded a value of +0.74 which signifies a high positive correlation.

The reliability of the questionnaires was carried out using internal consistency reliability after administering the instrument to 20 respondents that have similar characteristics as those that were involved in this study. The reliability coefficient was calculated using Cronbach's alpha and the SPCM and SPMM yielded a coefficient of 0.83 and 0.85 respectively. These high and positive value is an indication that questionnaires are reliable for the study. To determine the reliability of the interview protocol, it was given to two lecturers in the Department of Science education who were provided with the activity checklist adopted from Castillo-Montoya (2016). An inter rater reliability which showed 0.73 agreement between the two raters.

Procedure for Data Collection

The researcher sought permission from appropriate authorities in the selected schools for their consent to participate in the research. The consent of the chemistry teachers and students in participating schools were sought to participate as research assistants and respondents respectively. The respondents were enlightened on the benefit of the study and were assured they would not be exposed to any risk throughout the period of the research. This notwithstanding, respondents' right to withdraw at any point in the research was made known to them. Respondents were also assured that their responses would remain confidential and only responses from respondents that duly signed the consent form were selected to participate in the study.

The concept map graphic organizer and mind map graphic organizer experimental groups were presented with the related maps a day to the lesson by the researcher. The control group were not presented with maps prior to teaching. The researcher developed concept map graphic

organizer and mind map graphic organizer including lesson plans for both experimental groups. These were used to present and guide instructions in four lessons during a period of two weeks, while the control group will be taught using the conventional teaching method. All the groups were taught by the chemistry teachers who served as research assistants. A pre-test was conducted by the researcher to determine the students' level of understanding of the concept to be taught and also establish if the groups were equivalent. During teaching, the experimental groups were taught using the map they were given prior to the lesson. The control groups were taught using conventional teaching methods and after the treatment, a post test was conducted.

The researcher administered the questionnaires to the mind map and concept map groups to seek their perception of the use of organizers they were exposed to. The researcher waited to retrieve the copies of the questionnaires to ensure 100% retrieval. Furthermore, the researcher obtained a list of 10 respondents that performed excellently and poorly in the post test as a focus group for interview. The selected students were obtained from the two experimental groups and were interviewed to elicit their views on the treatment they were exposed to. Their responses were transcribed for further analysis. Data from both the quantitative and qualitative processes were used to interpret and discuss the findings from this study.

Data Analysis Techniques

Data collected from the quantitative aspect of this research were analyzed using descriptive of mean and standard deviation while inferential statistics involving t-test, and ANCOVA were used to test the hypotheses at 0.05 alpha level of significance. One way ANCOVA was used to test hypotheses 1,2, and 3 respectively since they involved one dependent and one independent variables while the pre test scores were considered as covariates. Hypotheses 4, 5, 6,7,8, 9, 10 and 11 were analyzed using t-test because they sought to establish the differences between two

independent variables. Responses from the focus group interview were analyzed using the qualitative approach of thematic analysis.

CHAPTER FOUR

DATA ANALYSIS AND RESULTS

This chapter presents the analysis of data collected during the study and the findings were presented based on the research questions raised and the research hypotheses formulated. Data obtained from quantitative aspect of the research were analyzed using mean, standard deviation, t-test and analysis of covariance (ANCOVA). The qualitative data obtained from interviews were transcribed and analyzed thematically.

Data Analysis

The demographic characteristics of the respondents presented in Table 7 showed that 77 (42.07%) of the participants were exposed to the use of concept maps graphic organizer, 44 (24.04%) were taught organic chemistry using mind maps graphic organizer and 62 (33.87%) were exposed to conventional teaching methods.

Table 7

Demographic Characteristics of Participants Based on Gender and Cognitive Styles

Groups	Gender		Cognitive Styles		Total
	Male	Female	Field Dependent	Field Independent	
Concept map	52(67.53%)	25(32.46%)	33(42.85%)	44(57.14%)	77(42.07%)
Mind map	26(59.09%)	18(40.90%)	19(43.18%)	25(56.81%)	44(24.04%)
Control	45(72.58%)	17(27.41%)	33(53.22%)	29(46.77%)	62(33.87%)
Total	123(67.21%)	60(32.78%)	85(46.44%)	98(53.55%)	183(100%)

Research Question 1: What is the effect of the use of concept map organizer on secondary school students' achievement in chemistry?

In response to this research question, data gathered from the post-test of the experimental group 1 (Concept map Organizer) and the Control Group (Conventional Method) were analyzed using mean and standard deviation as shown in Table 8. Results indicated that students in the Concept map group had a better achievement ($M=21.12$, $SD=7.17$) than their counterparts that were in the control group with a difference of 2.33.

Table 8

Mean and Standard Deviation of Students' Achievement when taught Organic Chemistry Using the Concept Map Graphic Organizer and Conventional Method.

Groups	N	Mean	SD	Difference
Concept Map	77	21.12	7.17	2.33
Control	62	18.79	4.28	
Total	139	20.08	6.14	

H_{01} : There is no significant difference in the achievement of secondary school students taught organic chemistry using concept map graphic organizer and those taught using the conventional method.

The pre-test and post-test scores of students in the two groups were further tested to determine if the difference was significant using ANCOVA. Table 9 revealed that $F_{(1,136)}= 10.37$, $p=.00$. The P-value of .00 which is less than the significant value is an indication that there was a statistically significant difference in the achievement of students taught organic chemistry using concept map graphic organizer and those taught using the conventional method. Hence, the null hypothesis was rejected. Therefore, there was a significant difference in the achievement of students taught organic chemistry and those taught using the conventional method. Table 9 further

revealed that the effect size is small showing a partial Eta Squared value ($\eta^2=.07$) which indicates that 7% of the variance in the students' achievement was due to the treatment (Concept map graphic organizer).

Table 9

Summary of Analysis of Covariance (ANCOVA) of Mean Scores of Students Taught Organic Chemistry Using Concept Map Graphic Organizer and Conventional Method

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	η^2
Corrected Model	860.41 ^a	2	430.20	13.42	.00	.16
Intercept	1562.07	1	1562.07	48.75	.00	.26
Pretest	674.50	1	674.50	21.05	.00	.13
Treatment	332.51	1	332.51	10.37	.00	.07
Error	4357.71	136	32.04			
Total	61259.00	139				
Corrected Total	5218.12	138				

Research Question 2: What is the effect of the use of mind map graphic organizer on secondary school students' achievement in organic chemistry?

Data gathered from the post-test of the experimental group 2 (Mind map graphic organizer) and the Control Group (Conventional Method) was used to respond to this research question. Data were analyzed using mean and standard deviation as shown in Table 10. Results revealed that students in the Mind map group performed better than their counterparts ($M=23.45$, $SD=4.60$) that were in the control group with a difference of 4.66.

Table 10

Mean and Standard Deviation of Students' Achievement when taught Organic Chemistry Using the Mind Map graphic Organizer and Conventional Method.

Groups	N	Mean	SD	Difference
Mind Map	44	23.45	4.60	4.66
Control	62	18.79	4.28	
Total	106	20.73	4.96	

H₀₂: There is no significant difference in the achievement of secondary school students taught organic chemistry using mind map graphic organizer and those taught using the conventional method.

Pre-test and post-test scores of students in the experimental group 2 and the control groups was tested to determine whether the difference was statistically significant using ANCOVA. Table 11 revealed that $F_{(1,103)} = 28.17, p = .00$. The P-value of 0.00 which is less than the significant value of .05 and this indicates that a statistically significant difference exist in the achievement of students taught organic chemistry using mind map organizer and those taught with the conventional method. Hence, the null hypothesis was rejected. Table 11 further revealed that the effect size is small showing a partial Eta Squared value ($\eta^2 = .21$). This effect size indicates that 21% of the variance in the students' achievement was traceable to the treatment (Mind map organizer).

Table 11

Summary of Analysis of Covariance (ANCOVA) of Mean Scores of Students Taught Organic Chemistry Using Mind Map Graphic Organizer and Conventional Method

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	η^2
Corrected Model	579.78 ^a	2	289.89	14.83	.00	.22
Intercept	3312.88	1	3312.88	169.48	.00	.62
Pretest	19.87	1	19.89	1.01	.31	.01
Treatment	549.78	1	549.78	28.12	.00	.21
Error	2013.28	103	19.54			
Total	48129.00	106				
Corrected Total	2593.06	105				

Research Question 3: What is the difference in the achievement of secondary school students that were taught organic chemistry using concept map graphic organizer and those taught using mind map organizer?

Table 12 shows analysis of data gathered from the post-test of the experimental group 1 (Concept map graphic organizer) and experimental group 2 (Mind map graphic organizer). Data was analyzed using mean and standard deviation as presented in Table 12. Results revealed that students in the experimental group 2 (Mind map graphic organizer) had better achievement ($M=23.45$, $SD=7.17$) than their counterparts that were in experimental group 1 (Concept map graphic organizer) with a difference of 2.33.

Table 12

Mean and Standard Deviation of Students' Achievement when taught Organic Chemistry Using the Concept map graphic Organizer and Mind map Graphic Organizer.

Groups	N	Mean	SD	Difference
Concept Map	77	21.12	7.17	2.33
Mind Map	44	23.45	4.60	
Total	121	21.97	6.44	

H₀₃: There is no significant difference in the achievement of secondary school students' inorganic chemistry when taught using concept map organizer and those taught using mind map graphic organizers.

Table 13 presents ANCOVA result for data gathered from the pre-test and post-test scores of students in experimental group 1 (Concept map graphic organizer) and experimental group 2 (Mind map graphic organizer) to find out if the difference was significant. Table 13 revealed that $F_{(1,118)} = 7.04$, $p = .00$. The P-value of 0.00 which is less than the significant value and this is an indication that there was a statistically significant difference in the achievement of students taught organic chemistry using concept map organizer and those taught using the mind map graphic organizer. Hence, the null hypothesis was rejected. Table 13 further revealed that the effect size is small showing a partial Eta Squared value ($\eta^2 = .05$) this indicates that 5% of the variance in the students' achievement was traceable to the treatment (Concept map graphic organizer).

Table 13

Summary of Analysis of Covariance (ANCOVA) of Mean Scores of Students Taught Organic Chemistry Using Mind Map Organizer and those Taught Using Mind Map Organizer

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	η^2
Corrected Model	578.34 ^a	2	289.17	7.75	.00	.11
Intercept	4479.24	1	4479.24	120.13	.00	.50
Pretest	425.33	1	425.33	11.04	.00	.08
Treatment	262.67	1	262.67	7.04	.00	.05
Error	4399.52	118	37.28			
Total	63366.52	121				
Corrected Total	4977.86	120				

Research Question 4: What is the perception of students on the use of concept map graphic organizer in learning organic chemistry?

Table 14 shows that students held a positive perception towards using concept map graphic organizer to study the chemistry of hydrocarbons this is evident in the grand mean of 3.24 which is above the benchmark of 2.50. It was revealed on Table 14 that majority of the respondents (91%) agreed with item 8 which also had the highest mean (M= 3.37). Table 14 also showed that the item with the least mean score is item 16 with 67% of the respondents agreeing with it.

Table 14

Mean and Standard Deviation of Students' Responses on Their Perception on the Use of Concept Map Organizer

Items	Perceived usefulness of Concept map Organizer	Mean	SD	Decision
1	I like using Concept map organizers because it aids learning at a glance	3.35	0.64	Positive
2	I enjoyed using Concept map for studying organic chemistry as it enabled me identify salient points in the lesson	3.25	0.63	Positive
3	Using Concept map organizer for studying organic chemistry helped me organize concepts related to organic chemistry	3.35	0.66	Positive
4	The use of Concept map organizers helped me understand the structures of the various classes of hydrocarbons	3.50	0.63	Positive
5	Using Concept map organizers helped me understand the chemistry of the various classes of hydrocarbons	3.28	0.75	Positive
6	When using Concept map organizer, organic chemistry concepts becomes more meaningful and understandable	3.34	0.66	Positive
7	A different strategy should have been used for me to understand the chemistry of hydrocarbon	2.91	0.94	Positive
8	Learning organic chemistry with Concept map organizer has made the topic one my favorite topics in chemistry	3.37	0.73	Positive
9	The use of Concept map organizer in studying organic chemistry helped me to maintain my concentration during learning	3.32	0.78	Positive
10	Using Concept map organizer to study organic chemistry makes learning experiences easier because it helps me to connect the relationships between concepts	3.35	0.69	Positive
Perception towards the use of Concept map Organizer in learning Organic chemistry				
11	I would willingly consider the use of Concept map organizer in learning other topics in chemistry because it is easy to use	3.21	0.78	Positive
12	It requires a lot of effort to study a Concept map organizer in order to understand related concepts in hydrocarbons.	3.04	0.76	Positive
13	Using mind maps organizer to study organic chemistry is time consuming and overwhelming	3.07	0.90	Positive
14	I prefer the constant use of Concept map organizer by my teacher than other strategies	3.09	0.79	Positive

Items	Perceived usefulness of Concept map Organizer	Mean	SD	Decision
15	The use of linking words in the maps facilitates my understanding of the relationship between organic chemistry concepts	3.40	0.69	Positive
16	The use of Concept map graphic organizer to study organic chemistry is a difficult procedure to follow	2.85	0.95	Positive
17	I benefitted a lot from the organic chemistry lesson when I used Concept map organizer, hence I prefer using it to other strategies	3.29	0.69	Positive
18	I prefer completing chemistry homework using Concept map organizer because it gives me direction on what I need to learn.	3.40	0.67	Positive
Total		3.24	0.76	

Research Question 5: What are the perceptions of students on the use of mind map graphic organizer in learning organic chemistry?

Table 15 reveals that students held positive perception towards using mind map graphic organizer to study the chemistry of hydrocarbons. This is apparent in Table 15 which presents a grand mean score of 3.13 which is above the 2.50 benchmark. It was revealed on Table 15 that majority of the respondents (92%) agreed with item 1 which was the item with the highest mean (M= 3.37). Findings also revealed that item 16 has the least mean score with 54% of the respondents in agreement.

Table 15

Mean and Standard Deviation of Students' Responses on Their Perception the Use of Mind Map graphic Organizer

Items	Perceived usefulness of Mind map Organizer	Mean	SD	Decision
1	I like using mind map organizers because it aids learning at a glance	3.37	0.85	Positive
2	I enjoyed using mind map for studying organic chemistry as it enabled me identify salient points in the lesson	3.26	0.79	Positive
3	Using mind map organizer for studying organic chemistry helped me organize concepts related to organic chemistry	3.24	0.78	Positive
4	The use of mind map organizers helped me understand the structures of the various classes of hydrocarbons	3.18	0.94	Positive
5	Using mind map organizers helped me understand the chemistry of the various classes of hydrocarbons	3.19	0.87	Positive
6	When using mind map organizer, organic chemistry concepts becomes more meaningful and understandable	3.06	0.96	Positive

Items	Perceived usefulness of Mind map Organizer	Mean	SD	Decision
7	A different strategy should have been used for me to understand the chemistry of hydrocarbon	2.95	0.93	Positive
8	Learning organic chemistry with mind map organizer has made the topic one my favorite topics in chemistry	3.16	0.89	Positive
9	The use of mind map organizer in studying organic chemistry helped me to maintain my concentration during learning	3.26	0.83	Positive
10	Using mind map organizer to study organic chemistry makes learning experiences easier because it helps me to connect the relationships between concepts	3.22	0.93	Positive
Perception towards the use of Mind map Organizer in learning Organic chemistry				
11	I would willingly consider the use of mind map organizer in learning other topics in chemistry because it is easy to use	3.21	0.91	Positive
12	It requires a lot of effort to study a mind map organizer in order to understand related concepts in hydrocarbons.	3.14	0.94	Positive
13	Using mind maps organizer to study organic chemistry is time consuming and overwhelming	2.86	1.02	Positive
14	I prefer the constant use of mind map organizer by my teacher than other strategies	2.95	0.93	Positive
15	The use of linking arrows in the maps facilitates my understanding of the relationship between organic chemistry concepts	3.32	0.87	Positive
16	The use of mind map graphic organizer to study organic chemistry is a difficult procedure to follow	2.54	1.08	Positive
17	I benefitted a lot from the organic chemistry lesson when I used mind map organizer, hence I prefer using it to other strategies	3.16	0.96	Positive
Total		3.13	0.93	

Research Question 6: What is the influence of gender on secondary school students' achievement in organic chemistry when taught using concept map graphic organizer?

Table 16 shows the mean achievement of male and female students' achievement when taught organic chemistry using concept map graphic organizer. Results from Table 16 revealed that female students had a higher mean gain score ($M = 7.16$) than their male counterparts ($M = 4.68$). The difference in the mean gain score of the two groups is 2.48 which is an indication that gender influenced the students' achievement in favour of the female students.

Table 16

Mean Gain Scores of Male and Female Students taught Organic Chemistry using Concept map graphic Organizer

Group	Group Statistic	Pretest	Posttest	Mean Gain Score	Difference
Male	N	52	52		
	Mean	16.17	20.85	4.68	
	SD	5.65	7.81		2.48
Female	N	25	25		
	Mean	14.52	21.68	7.16	
	SD	4.88	5.72		

H04: There is no significant difference in the achievement of male and female secondary school students when taught organic chemistry using concept map graphic organizer.

Table 17 shows an Independent *t*-test analysis of male and female students' achievement in organic chemistry. Results revealed that there was no significant difference in male and female students' achievement at a *t*-value $t_{(75)} = .47$, $P = .63$. Since the *P*-value of 0.63 was greater than .05 alpha level, the null hypothesis was not rejected. There is therefore no significant difference in the

achievement of male and female students taught organic chemistry using the concept map graphic organizer.

Table 17

Independent Samples t-test of male and female Students Achievement Taught to Organic Chemistry Using Concept map graphic Organizer

Treatment	Gender	N	M	SD	df	t	Sig.	Remark
Concept map	Male	52	20.85	7.18	75	-.47	.63	NS
	Female	25	21.68	5.72				

Research Question 7: What is the influence of gender on secondary school students' achievement in organic chemistry when taught using mind map graphic organizer?

Table 18 presents the mean of male and female students' achievement in organic chemistry when taught using mind map. Results from Table 18 revealed that female students had a higher mean gain score (M= 10.89) than their male counterparts (M= 9.58). The difference in the mean gain score of the two groups is 1.31 which indicates that gender positively influenced the students' achievement in favour of the female students.

Table 18

Mean Gain Scores of Male and Female Students taught Organic Chemistry using Mind map graphic Organizer

Group	Group Statistic	Pretest	Posttest	Mean Gain Score	Difference
Male	N	26	26		
	Mean	13.50	23.08	9.58	
	SD	5.64	3.69		1.31
Female	N	18	18		
	Mean	13.11	24.00	10.89	
	SD	5.77	5.75		

H0₅: There is no significant difference in the achievement of male and female secondary school students when taught organic chemistry using mind map graphic organizer.

Table 19 shows an Independent *t*-test analysis of male and female students' achievement in organic chemistry when taught with mind map organizer. The results revealed that there is no significant difference in the achievement of male and female students at a *t*-value $t_{(42)} = .64$, $P = .52$. Since the *P*-value of 0.52 is greater than .05 alpha level and thus the null hypothesis is not rejected. There is therefore no significant difference in the achievement of male and female students taught organic chemistry using the mind map graphic organizer.

Table 19

Independent Samples t-test of male and female Students Achievement Taught to Organic Chemistry Using Mind map graphic Organizer

Treatment	Gender	N	M	SD	df	T	Sig.	Remark
Mind map	Male	26	23.08	3.69	42	-.64	.52	NS
	Female	18	24.00	5.75				

Research Question 8: What is the influence of cognitive styles on secondary school students' achievement in organic chemistry when taught using concept map graphic organizer?

Table 20 shows the means of the achievement of field dependent (FD) and field independent (FI) students' when they were taught organic chemistry using concept map graphic organizer. Results from Table 20 indicated that the FI students had a higher mean gain score ($M = 5.73$) than their FD counterparts ($M = 5.16$). The difference in the mean gain score of the two groups is 0.57 which implies that cognitive styles positively influenced the students' achievement in favour of the FI students.

Table 20

Mean Gain Scores of Field dependent and Field independent Students taught Organic Chemistry using Concept map graphic Organizer

Group	Group Statistic	Pretest	Posttest	Mean Gain Score	Difference
Field Dependent	N	33	33		
	Mean	14.48	19.64	5.16	
	SD	4.15	5.33		0.57
Field Independent	N	44	44		
	Mean	16.50	22.23	5.73	
	SD	6.13	8.17		

H₀₆: There is no significant difference in the achievement of field dependent and field independent secondary school students in organic chemistry when taught using concept map graphic organizer

Table 21 shows an Independent *t*-test analysis of FD and FI students' achievement in organic chemistry. Results revealed that there was no significant difference in FD and FI students' achievement at a *t*-value $t_{(75)} = 1.58$, $P = .11$. Since the *P*-value of 0.11 is greater than .05 alpha level, the null hypothesis was not rejected. Therefore, there is no significant difference in the achievement of FD and FI students taught organic chemistry using the concept map graphic organizer.

Table 21

Independent Samples t-test of Field dependent and Field independent Students' Achievement Taught to Organic Chemistry Using Concept map graphic Organizer

Treatment	CogSty	N	M	SD	df	T	Sig.	Remark
Concept map	FD	33	19.64	5.33	75	-1.58	.11	NS
	FI	44	22.23	8.17				

Research Question 9: What is the influence of cognitive styles on secondary school students' achievement in organic chemistry when taught using mind map graphic organizer?

Table 22 shows the mean of field dependent (FD) and field independent (FI) students' achievement when taught organic chemistry using mind map organizer. Results from Table 22 revealed that the FI students had a higher mean gain score ($M= 10.08$) than their FD counterparts ($M= 9.21$). The difference in the mean gain score of the two groups is 1.59 which implies that cognitive styles positively influenced the students' achievement. This influence is in favour of the FI students.

Table 22

Mean Gain Scores of Field dependent and Field independent Students taught Organic Chemistry using Mind map graphic Organizer

Group	Group Statistic	Pretest	Posttest	Mean Gain Score	Difference
Field Dependent	N	19	19		
	Mean	15.42	24.63	9.21	
	SD	5.43	5.52		1.59
Field Independent	N	25	25		
	Mean	11.76	22.56	10.8	
	SD	5.38	3.64		

H_{07} : There is no significant difference in the achievement of field dependent and field independent secondary school students in organic chemistry when taught using mind map graphic organizer

Table 23 shows an Independent *t*-test analysis of FD and FI students' achievement in organic chemistry. Results revealed that there is no significant difference in FD and FI students'

achievement at a t -value $t_{(42)} = 1.49$, $P = .14$. Since the P -value of 0.14 was greater than .05 alpha level, thus, the null hypothesis is not rejected. There is therefore no significant difference in the achievement of FD and FI students taught organic chemistry using mind map graphic organizer.

Table 23

Independent Samples t -test of Field dependent and Field independent Students' Achievement Taught to Organic Chemistry Using Mind map graphic Organizer

Treatment	CogSty	N	M	SD	df	t	Sig.	Remark
Mind map	FD	19	24.63	5.52	42	1.49	.14	NS
	FI	25	22.56	3.64				

Research Question 10: What influence does secondary school students' gender have on their perception on the use of concept map graphic organizer in learning organic chemistry?

Results of the mean and standard deviation of students' response on their perception on the use of concept map graphic organizer are presented in Table 24. These results reveals that the means score of students' perception is higher for female students ($M = 81.64$, $SD = 3.64$) than for their male counterparts ($M = 80.80$, $SD = 9.73$). This indicates that gender positively influenced students' perception in favour of the female students

Table 24

Mean and Standard Deviation of Male and Female Students' Responses on their Perception on the use of Concept map graphic Organizer in Learning Organic Chemistry

Treatment	Gender	N	Mean	Std. Dev
Concept map	Male	45	80.80	9.73
	Female	23	81.64	3.64

H₀₈: There is no significant difference in the perception of male and female secondary school students on the use of concept map organizer in learning organic chemistry

Table 25 shows an Independent *t*-test analysis of male and female students' responses on their perception in learning organic chemistry using concept map graphic organizer. The results revealed that there is no significant difference in the responses of male and female students' with respect to their perception at a *t*-value $t_{(66)} = 0.34$, $P = .73$. The *P*-value of 0.73 was greater than .05 alpha level, and thus the null hypothesis is not rejected. There is therefore no significant difference in the responses of male and female students on their perception of learning organic chemistry using concept map graphic organizer.

Table 25

Independent Samples t-test of Male and Female Students' Responses on their Perception on the Use of Concept map graphic Organizer in Learning Organic Chemistry

Treatment	Gender	N	M	SD	df	t	Sig.	Remark
Concept map	Male	45	80.80	9.73	66	-.34	.73	NS
	Female	23	81.64	3.64				

Research Question 11: What influence does secondary school students' gender have on their perception on the use of mind map graphic organizer in learning organic chemistry?

Table 26 shows result of the mean and standard deviation of students' response on their perception on the use of mind map graphic organizer. The results reveals that the means score of students' perception was higher for female students ($M = 78.30$, $SD = 15.52$) than their male counterparts ($M = 78.21$, $SD = 12.91$). This indicates that gender positively influenced students' perception in favour of the female students.

Table 26

Mean and Standard Deviation of Male and Female Students' Responses on their Perception on the use of Mind map graphic Organizer in Learning Organic Chemistry

Treatment	Gender	N	Mean	Std. Dev
Mind map	Male	16	78.21	12.91
	Female	45	78.30	15.52

H_{09} : There is no significant difference in the perception of male and female secondary school students on the use of mind map graphic organizer in learning organic chemistry

Table 27 shows an Independent *t*-test analysis of the responses of male and female students' responses on their perception of learning organic chemistry using concept map graphic organizer. The results revealed that there is no significant difference in the responses of male and female students' on their perception at a *t*-value $t_{(59)} = -0.21$, $P = .98$. The *P*-value of 0.21 is greater than .05 alpha level, the null hypothesis was not rejected. There is thus, no significant difference in the responses of male and female students on their perception of learning organic chemistry using mind map graphic organizer.

Table 27

Independent Samples t-test of Male and Female Students' Responses on their Perception on the Use of Mind map graphic Organizer in Learning Organic Chemistry

Treatment	Gender	N	M	SD	df	t	Sig.	Remark
Mind map	Male	16	78.21	12.91	59	-.02	.98	NS
	Female	45	78.30	15.52				

Research Question 12: Does secondary school students' cognitive styles influence their perception on the use of concept map graphic organizer in learning organic chemistry?

The result of the mean and standard deviation of students' responses with respect to their perception on the use of concept map organizer are presented in Table 28. The results revealed that the mean score of students' perception was higher for FD students (M= 82.23, SD= 7.82) than for their FI counterparts (M= 80.23, SD= 10.57). This indicates that cognitive style of students positively influenced their perception on the use of concept map organizer in favour of field dependent students.

Table 28

Mean and Standard Deviation of Field dependent and Field independent Students' Responses on their Perception on the use of Concept map graphic Organizer in Learning Organic Chemistry

Treatment	CogStyl	N	Mean	Std. Dev
Concept map	FD	29	82.23	7.82
	FI	39	80.23	10.57

H_{010} : There is no significant difference in the perception of field dependent and field independent students on the use of concept map graphic organizer in learning organic chemistry

Table 29 shows an Independent t -test analysis of field dependent and field independent students' responses on their perception in learning organic chemistry using concept map graphic organizer. The results revealed that there is no significant difference in the responses of field dependent and field independent students on their perception at a t -value $t_{(66)} = 0.85$, $P = .39$. The P -value of 0.39 was greater than .05 alpha level, and the null hypothesis is not rejected. There is therefore no significant difference in the responses of field dependent and field independent students on their perception of learning organic chemistry using concept map organizer.

Table 29

Independent Samples t-test of Field dependent and Field independent Students' Responses on their Perception on the Use of Concept map graphic Organizer in Learning Organic Chemistry

Treatment	CogStyl	N	M	SD	df	t	Sig.	Remark
Concept map	FD	29	82.23	7.82	66	.85	.39	NS
	FI	39	80.23	10.57				

Research Question 13: Does secondary school students' cognitive styles influence their perception on the use of mind map graphic organizer in learning organic chemistry?

Table 30 shows result of the mean and standard deviation of students' response on their perception on the use of mind map organizer. The results revealed that the means score of students' perception was higher for FD students (M= 78.71, SD= 14.62) than their FI counterparts (M= 77.82, SD= 15.16). This indicate that cognitive style positively influences students' perception in favour of the field dependent students

Table 30

Mean and Standard Deviation of Field dependent and Field independent Students' Responses on their Perception on the use of Mind map Organizer in Learning Organic Chemistry

Treatment	CogStyl	N	Mean	Std. Dev
Mind map	FD	31	78.71	14.62
	FI	30	77.82	15.16

H_{011} : There is no significant difference in the perception of field dependent and field independent students on the use of mind map organizer in learning organic chemistry

Table 31 shows an Independent *t*-test analysis of field dependent and field independent students' responses on their perception in learning organic chemistry using mind map as an

advance organizer. Findings revealed that there was no significant difference in the responses of field dependent and field independent students on their perception at a t -value $t_{(59)} = 0.23$, $P = .81$. Since the P -value was greater than .05 alpha level, the null hypothesis was not rejected. Hence, there is no significant difference in the responses of field dependent and field independent students on their perception on learning organic chemistry using mind map organizer.

Table 31

Independent Samples t-test of Field dependent and Field independent Students' Responses on their Perception on the Use of Mind map Organizer in Learning Organic Chemistry

Treatment	CogStyl	N	M	SD	df	t	Sig.	Remark
Mind map	FD	31	78.71	14.62	59	.23	.81	NS
	FI	30	77.82	15.16				

Research Question 14: What are the experiences of students on their exposure to organic chemistry when taught using the concept map organizer?

The thematic analysis of students' responses on their learning experiences using concept map organizer in learning organic chemistry presented on Table 32 revealed five themes that were generated from ten sub-themes. The themes included (i) support for cognitive development (ii) areas of difficulties (iii) implications for affective domain of learning (iv) support for use of maps (v) shortcomings for use of maps. These themes were generated inductively from emerging codes in the transcript. Results revealed that 80% of the students' held positive opinions on the use of concept map graphic organizers to learn organic chemistry for instance, they noted that the maps were able to support their learning through the use of linking phrases. Although they noted some shortcomings such as difficulties in understanding some new terms that are in the map while studying prior to the lesson.

Table 32

Thematic Analysis of Students' Responses about their Experience with using Concept map Organizer to Learn Organic Chemistry

Themes	Sub Themes	Samples of Students' Responses
Support for cognitive development	Facilitates learning	"...the concept map was helpful in naming organic compounds". "The concept maps were useful for me because it gave very brief explanation in a way that I understand. "I understood the contents of the map that is how hydrocarbons come in groups and classes as in the examples made it to be clearer to me." "The concept map was detailed to show that hydrocarbons contain hydrogen and carbon and are divided into two major classes."

Themes	Sub Themes	Samples of Students' Responses
	Identification of relationships among concepts	"The words in between the arrows on the map were important clue to me for understanding the content of the map." "I had more information on the map because I was able to relate the examples for each of the classes and reaction that occurs for each homologous series." "...I was able to identify the examples and the various classes with words on the arrows that were explaining them." "I got directions from the map showing arrows pointing how different concepts on the maps are related."
	Processing information on the maps	"The concept map brings information straight and make it easier to grasp more than using the textbooks." "I understand the examples that were cited in the map for the various classes but it was when the teacher explained that I understood better." "Umm , for me, about the concept map, it is not that the map is not good and one can understand the content of the map..."
	Reference to prior knowledge	"...the map was explicit because it was simple to explain that hydrocarbon contains hydrogen and oxygen. These two elements are what I was already familiar with and I was able to pick up from there." "I don't understand some things due to the terminologies that were strange to me. For instance it was easy for me to understand addition reaction while other were a little bit difficult for me to comprehend e.g polymerization reactions." "...but those familiar words that were in the map were what assisted me to understand the content of the map immediately my teacher started discussing them in class."
Areas of difficulty	Identification of difficult areas	"...there is an area I found difficult and that is Umm... the reactions that alkanes undergo. For instance in the substitution reaction of ethane, the products and the processes for each of the stages" "...the members of the homologous series are confusing to me."
Implications for affective	Development of interest	"The teachers' flex showing the concept map was captivating." "Emmm, it was a good and easy experience to work with the concept map" "...Using the maps to learn organic chemistry was interesting"

Themes	Sub Themes	Samples of Students' Responses
domain of learning	towards chemistry	"...It is interesting to use."
Support for use maps	Preference for use maps	"I will like to say that I will prefer that when my teacher has explained the new topic, he may use the maps to summarize his lessons..." "I will prefer using it before coming to class so that I will have noted my areas of concern that I want to ask my teacher." "I think that I should be taught without the map. But the maps should be given to me after the class or during revision." "...using the map before the class was boring because of some new terminologies in it. I will prefer using the map after my teacher has taught."
Shortcomings for use of maps	Discourage using maps for learning	"...continuous use of the map will create an addiction towards it. In an event when I don't have the maps anymore it may be difficult for me to learn without it" "it was not a good tool to start the learning of organic chemistry. This is because some of the terminologies were so strange..." "In an event when I don't have the maps anymore it may be difficult for me to learn without it and this will affect my general performance in chemistry"
	Barriers to learning with the map	"I had difficulty in translating some of the questions asked by my teacher to a simpler way for me to understand so I became confused at some point." "Some of the things that caused difficulty for me were the fact that I don't understand some things due to the terminologies that were strange to me" "I forget the meaning of some of the concepts easily and it takes some time for me to remember them especially when the teacher is referring to them in the class."
	Decline for subsequent use of maps	"No, I will not like to use it prior to class. That map will deprive me of my attention in class because I will be proud that I have an idea of what my teacher wants to teach..." "Yes, I will use it but I will prefer using it before coming to class so that I will have noted my areas of concern that I want to ask my teacher."

Research Question 15: What are the experiences of students on their exposure to organic chemistry when taught using the mind map organizer?

Table 33 presents thematic analysis of students' responses on their learning experiences using mind map organizer in learning organic chemistry. Five themes emerged from eight sub-themes that were inductively generated from students' responses. The themes included (i) support for cognitive development (ii) areas of difficulties (iii) implications for affective domain of learning (iv) support for use of maps (v) shortcomings for use of maps. The results revealed that 90% of the respondents held positive opinion about the use of mind map graphic organizer in learning organic chemistry. For instance, responses revealed that students established relationships among concepts in the map. However, they claimed that they assumed understanding of the contents of the map, as such, they paid less attention during the lesson.

Table 33

Thematic analysis of students' responses about their experience with using mind map graphic organizer to learn organic chemistry

Themes	Sub Themes	Samples of Students' Responses
Support for cognitive development	Facilitates learning	"The maps I worked with made me to assimilate easily" "I think I had a better understanding when I studied with the maps" "...understanding of some chemistry topics is low but with the map I worked with, I was able to understand better." "I was able to understand the reactions that each of the homologous series undergoes before the class."
	Identification of	"Yes, it helped me to understand the classes by showing them and the reactions that each homologous series undergoes"

Themes	Sub Themes	Samples of Students' Responses
	relationships among concepts	"...It also makes the topic more easy because it shows how this relates to that" "I was able to avoid some misconceptions about the concept of saturated and unsaturated because they look similar. But the map has assisted me to clearly differentiate them." "Umm... the classification of the organic chemistry was so complex.....but the map put each of the classes in their various categories in a more simple form."
	Processing information on the maps	"To me, the maps speed up my rate of understanding hydrocarbons..." "...the maps have exposed me to understand the derivatives of benzene. The examples are helpful." "We should be using it because it does not make the topic complex." "Yes, it was pointing to important points instead of reading a large volume of books" "Yes, we can be using it because the maps have summarized all the points that we need to learn."
Areas of difficulty	Identification of difficult areas	"According to me, I understood what she taught but some aspect are not clear and those area include metamers, geometric isomerism" "Areas such as cis and trans isomerism were not clear, but I got the area of nomenclature correctly." "...I also think the reason for the difficulty is because those areas were becoming complex so it is getting tough to understand"
Implications for affective domain of learning	Development of interest towards chemistry	"...it arouses my interest about organic chemistry." "I was curious and want to find out how my teacher will use the map. So, I think I paid more attention to the lesson" "I think we should be using it to learn on our own so that if the teacher comes to class to explain it will be easier to understand and learning will be interesting."
Support for use maps	Preference for use maps	"We should be using it because it does not make the topic complex." "Yes, we can be using it because the map have summarized all the points that we need to learn."

Themes	Sub Themes	Samples of Students' Responses
		"I think we should be using it to learn on our own..."
Shortcomings for use of maps	Discourage using maps for learning	"I think using it before the class should be discouraged because having access to the map drove my attention away from the class... I assumed I have idea of what the teacher will be teaching for the class." "What I have to say is that the maps are good but it should be used for only the complex topics but other topics may not necessarily need it."
	Barriers to learning with the map	"It is the time,the time for the explanation does not seems to be enough. I mean it was too short. I was able to understand just the basics. I also think the reason for the difficulty is because those areas were becoming complex so it is getting tough to understand."

Summary of Findings

The following are the summary of the findings in this study:

1. There was a significant difference in the achievement of students taught organic chemistry using concept map graphic organizer and those taught with the conventional method $F_{(1,136)} = 10.37, p < .05, \eta^2 .07$.
2. There was a significant difference in the achievement of students taught organic chemistry using mind map graphic organizer and those taught with the conventional method $F_{(1,103)} = 28.17, p < .05, \eta^2 .21$.
3. There was a significant difference in the achievement of students taught organic chemistry using concept map graphic organizer and those taught using mind map graphic organizer $F_{(1,118)} = 7.04, p < .05, \eta^2 .05$.
4. Students held positive perception towards using concept map graphic organizer for their learning of organic chemistry.
5. Students held positive perception towards the use of mind map graphic organizer for their learning of organic chemistry.
6. There was no significant difference in the achievement of male and female students' when they were taught organic chemistry using the concept map graphic organizer
7. There was no significant difference in the achievement of male and female students' when they were taught organic chemistry using the mind map graphic organizer
8. There was no significant difference in the achievement of field dependent cognitive style and field independent cognitive style students taught organic chemistry using concept map graphic organizer

9. There was no significant difference in the achievement of field dependent cognitive style and field independent cognitive style students taught organic chemistry using mind map graphic organizer
10. There was no significant difference in the perception of male and female students on the use of concept map graphic organizer
11. There was no significant difference in the responses of male and female students on their perception on learning organic chemistry using mind map graphic organizer
12. There was no significant difference in the responses of field dependent cognitive style and field independent cognitive style students' responses on their perception of learning organic chemistry using concept map graphic organizer
13. There was no significant difference in the perception of field dependent cognitive style and field independent cognitive style students on the use of mind map graphic organizer
14. Students exposed to using concept map graphic organizer expressed significant learning experience which were categorized into five themes and ten sub themes.
15. Eight sub themes and five themes were identified in students' responses on their experience when exposed to using mind map graphic organizer which indicated a significant learning experience.

CHAPTER FIVE

DISCUSSION, CONCLUSION AND RECOMMENDATIONS

This chapter presents a discussion of the findings from this study. Conclusion was drawn and relevant recommendations have been made.

Discussion

This study investigated the effect of graphic organizer on secondary school students' achievement in organic chemistry. The graphic organizers that were investigated in this study were concept map and mind map which served as advance organizers. The findings of this study revealed that concept organizer improved students' achievement in organic chemistry. That is, students taught organic chemistry using concept map graphic organizer had better achievement than their counterparts in the control group. This could be attributed to the fact that students in the concept map graphic organizer group utilized the maps as advance organizer which gave them an idea of what they should be doing in the next lesson. Also, students worked with the maps during lesson presentation and as such concretized their learning. Excerpts from the interview revealed that students identified that the maps when used as advance organizer were supportive to enable them to gain more from their teacher's explanation.

Respondent G: *"...I have noted my areas of concern that I want to ask my teacher while studying the maps alone"*.

Respondent C: *"...when I was studying with the maps, I think I understood it on its own because I was able to identify the examples and the various classes using the words on the arrows that were pointing at them"*

Such is an indication that students in the concept map graphic organizer group were able to study the maps to identify relationships among various concepts in the map prior to instruction. This was evident from the responses of the participants of their perception on item 6 of the questionnaire, "when using concept map organizer, organic chemistry concept becomes more

meaningful and understandable”. Their responses had a mean score that is above the benchmark and this indicated that participants in this group held positive perception towards use of concept map graphic organizer to facilitate their learning of organic chemistry. The implication of this is that concept map enhanced better understanding of organic chemistry than the conventional method. This finding is consistent with the findings of Bamidele, Adetunji, Awodele and Irinoye (2013) who reported that mapping strategies when used as advance organizer enhanced students’ performance in chemistry since it shows clarity in the relationship between key concepts that are on the map. Chawla and Singh (2015) had also reported that concept map graphic organizer is a significant tool in improving students’ achievement in chemistry.

Findings from this study also showed that there was a significant difference between the achievements of students’ taught organic chemistry using mind map graphic organizer and those taught using the conventional method. This implies that students’ in this group performed better than their counterparts in the control group. A possible reason for this is the ability of the students to familiarize themselves with information about the next lesson by studying their mind maps graphic organizer before coming to class and their encounter with the map during instruction. Excerpts from the interview sessions revealed that students’ benefitted more from the lesson as a result of their prior exposure to mind maps graphic organizer before and also during instruction.

Respondent T: *“The maps I studied before the class made organic chemistry easy to understand. My understanding of some chemistry topics is low but with the map I worked with, I was able to understand better.”*

Respondent A: *“Umm... the classification of the organic chemistry was so complex.....but the map put each of the classes in their various categories in a more simple form.”*

Respondent Z: *“I was able to avoid some misconceptions about the concept of saturated and unsaturated because they look similar. But the map has assisted me to clearly differentiate them.”*

These responses showed that mind map graphic organizer enhanced the students' achievement in organic chemistry when compared with students in the conventional method who were not taught using the organizer. Also, responses of students on item 1 (“I like using mind map organizer because it aids learning at a glance”) of the questionnaire indicated positive perception of the use of mind map graphic organizer in learning organic chemistry. In earlier studies, Adodo (2013) reported that mind mapping strategy has the capacity of improving students' critical thinking, creative skills as well as improving their performance in basic science. Finding from the present study had confirmed such supposition especially in learning organic chemistry. Gajiz, et. al (2019) also made similar observation in physics.

The findings of this study showed a significant difference existing between the achievements of students who were taught organic chemistry using concept map graphic organizer and those taught using the mind map graphic organizer in favour of the mind map graphic organizer group. This finding could be attributed to lack of linking phrases in the mind map graphic organizer which prompted students to brainstorm the relationships between the concepts on their map. This act of brainstorming could probably concretize their knowledge of organic chemistry much better than participants in the concept map graphic organizer group whose maps already made provision for the type of relationships that exists between the concepts in their maps through linking phrases. Besides, excerpts from the interview revealed that mind map graphic organizer spurred interest and arouse curiosity when used and this could also be one of the reasons for the improved achievement for the group of mind map graphic organizer.

Respondent Q: *“My encounter with the map spurred some excitement in me. Umm...in the first instance, I was curious and want to*

find out how my teacher will use the map. So, I think I paid more attention in the class.”

It was the experience and view of the concept map graphic organizer group that details provided on their map in terms of linking phrases provided information about relationships among concepts in the maps and hence assured them confidence of understanding the content of the maps before the class, consequently, they paid less attention and showed less commitment in the class in contrast with students in the mind map graphic organizer group.

Respondent T: “...the map deprived me of my attention in class because I was proud that I have idea of what he wants to teach and my concentration was divided in the class...”

Mind map has showed in this study that it is an effective tool for teaching chemistry due to the fact that less information is provided and as such, more mental effort is required of the students than the concept map graphic organizer group. It is not surprising therefore that students held positive perception towards item 12 (“it requires a lot of effort to study a mind map organizer in order to understand related concepts in hydrocarbons”) whose mean score has been reported to be above the average benchmark. While both graphic organizers developed were to have pedagogical function which serves as a technique for presenting instruction and assess students’ understanding of information, mind maps are developed with intents to develop skills for brainstorming. The findings of this study is in agreement with those of Aydin (2015) who found that technology-supported mind mapping strategy enhanced students’ performance in science learning better than technology-supported concept mapping strategy.

It was found in this study that chemistry students generally held positive perception towards usefulness and subsequent use of concept map graphic organizer as a learning tool for organic chemistry. Item 8 (“learning organic chemistry with concept map organizer made the topic

one of my favorite topics in chemistry”) attracted the highest mean score from the respondents. This indicated that majority of the respondents (91%) agreed with this item due to the extra support that students got from the concept maps through clarity in identification of relationships among concepts. Their motivation towards studying with concept map graphic organizer was aroused as shown in the following interview interaction.

Respondent H: *“Emmm, it was a good and easy experience to work with the concept map....I found it interesting. The teachers’ flex showing concept map was captivating”*

Respondent C: *“...using maps to learn organic chemistry was interesting”*

Findings from this study revealed that students’ held positive perception towards the use of mind maps as a learning tool in studying organic chemistry. This positive disposition could be attributed to the assistance students’ believed to have obtained as a result of working with a mind map graphic organizer and as a supplementary tool in the classroom instruction. It is not surprising that highest proportion of students (92%) agreed to item 1 on the questionnaire which stated that: “I like using mind map organizers because it aids learning at a glance”. This can be spelt out in a sample of the students’ responses during interview sessions, where they indicated how the mind maps have assisted them to learn organic chemistry.

Respondent I: *“Yes, it helped me to understand the classes by showing them and the reactions that each homologous series undergoes...”*

Respondent X: *“I was able to understand the reactions that each of the homologous series undergoes before the class.”*

Respondent Z: *“To me, the maps speed up my rate of understanding hydrocarbons. I was able to understand and assimilate the classes of hydrocarbons easily.”*

The implication of these claims is that mind map graphic organizer was an effective tool for students’ learning of organic chemistry in secondary schools. Recently, Rahmad (2019)

reported that students' held positive perception of their use of mind mapping application software in learning writing. Ravindranath et. al. (2016) had earlier reported positive perception of students towards the use of mind mapping in problem based learning. The findings of the present study have provided further empirical data that perception of students on the use of graphic organizers is very important and the more students are positively disposed to its use, the better they are able to utilize it for improving their achievement in chemistry.

Learning experiences of the students' were broadly categorized into five major themes in which three of the themes were recognized to provide strength for using concept maps graphic organizer to learn organic chemistry by 80% of the respondents;(support for cognitive development, implications for affective domain of learning, support for use of maps).However, two of the themes identified were directed towards the weakness of the map expressed by 20% of the students;(acknowledged areas of difficulties, and shortcomings for using maps). It is important to note that the five themes were generated from ten subthemes out of which the theme (support for cognitive development) had four of the subthemes. It is therefore, an indication that most of the responses from the participants focused on the positive role of concept maps towards understanding of organic chemistry. Excerpts from the focus group indicated some of the students' responses.

Respondent F: *"...the concept maps were useful for me because it gave very brief explanation in a way that I understand. For instance the concept map showed the classes of the hydrocarbons in a way that was glaring any easy to understand..."*

Respondent G: *“...my experience using it is that a continuous use will create an addiction. In an event when I don't have the maps, it may be difficult for me to learn without it”*

Students' learning experiences on the use of mind map graphic organizer were broadly categorized into five major themes in which three of the themes; (support for cognitive development, implications for affective domain of learning, support for use of maps) were recognized to provide support for students' understanding of organic chemistry. Ninety percent (90%) of the respondents in the interview provided responses related to this claim. However, two of the themes identified were directed towards the weakness of the map expressed by 10% of the students; (acknowledged areas of difficulties, and shortcomings for using maps). It is important to note that the five themes were generated from eight subthemes out of which the theme (support for cognitive development) had three of the subthemes. It is therefore, an indication that responses from the participants focused on the positive role of mind maps graphic organizer towards understanding of organic chemistry. Excerpts from the focus group indicated some of the students' responses.

Respondent G: *“Umm the classification of organic chemistry was so complex....but the map put each of the classes in their various categories in a more simple form”*

Respondent K: *“it is the time....I mean it was too short”*

The present study revealed that there was no significant difference in the achievement of male and female students when they were taught organic chemistry using the concept map organizer. The finding might not be unconnected with the fact that both male and female students were exposed to the same treatment and there was no preference for a particular group based on their gender. Both groups therefore had equal advantage towards using the graphic organizer. The pedagogical implication of this finding is that concept map graphic organizer can be used in

classrooms that have both male and female students. This finding is consistent with that of Gongden and Delmang (2016) who reported that there was no significant difference in the performance of male and female students' when taught chemistry using concept mapping instructional strategy. However, Ariaga and Nwanekezi (2018) differ in their report that revealed a significant difference when students were taught organic chemistry using the concept mapping instructional strategy.

Finding from the present study also revealed that there was no significant difference in the achievement of male and female students that were taught organic chemistry using mind map graphic organizer. This finding could be as a result of the fact that the use of mind map graphic organizer in lesson delivery allows students from both gender group to participate effectively in the lesson without preference for a particular group. This connotes that mind map graphic organizer can be adopted in a regular classroom setting with mixed gender students. This finding is in agreement with the findings of Adodo (2013) that reported no significant difference in the performance of students taught basic science and technology using mind mapping strategy. On the contrary, the findings of Okeke (2011) differs by reporting a significant difference in the achievement of male and female students taught chemistry using the mind mapping strategy which was in favour of the female students.

Findings also revealed that there was no significant difference in the achievement of field dependent cognitive style and field independent cognitive style students taught organic chemistry using concept map graphic organizer and those taught using mind map graphic organizer. This finding could be due to the fact that concept map graphic organizer as well as mind map graphic organizer allows students of different cognitive styles to process information in their unique ways. This indicates that both graphic organizers can enhance students' understanding of chemistry when

used in classrooms with varying cognitive styles. This finding is in contrast with findings of Idika (2017) who reported that there was significant difference in the achievement of secondary school students' chemistry in favour of the field independent students.

Further findings from the study revealed that students held positive perception to the use of concept map graphic organizer and mind map graphic organizer and there was no significant difference in the perception of male and female students on the use of both concept map graphic organizer and mind map graphic organizer. This could be as a result of the exposure of both male and female students in the two groups to the same learning experiences using concept map graphic organizer and mind map graphic organizer respectively. Lok (2014) had earlier reported that students held positive perception towards the use of concept mapping strategy in learning chemistry. Similarly, Rahmad (2019) also reported that mind map helped students to benefit from learning material and as such students held positive perception towards it.

There was no significant difference in the responses of field dependent cognitive style and field independent cognitive style students' responses on their perception of learning organic chemistry using concept map graphic organizer and mind map graphic organizer. This could be due to the fact that the use of the graphic organizers allowed students to process information on the graphic organizer in their own preferred way. As a result of this, students attained understanding of the content of instruction irrespective of their cognitive styles.

Conclusion

Based on the findings from this study, it can be concluded that graphic organizers are effective tools that have positive effect on students' achievement in organic chemistry. Both graphic organizers had significant effect on students' achievement when taught organic chemistry

compared to students' taught without graphic organizers (control group). It was found however, that students' performance in organic chemistry when taught using mind map graphic organizer was better than their counterparts that were taught using concept map graphic organizer. Variables such as gender and cognitive styles did not influence students' achievement in organic chemistry. It can also, be concluded that students held positive perception on the use of graphic organizers in learning organic chemistry. Furthermore, students expressed positive opinions about their experience when using graphic organizers to learn organic chemistry.

Recommendations

Based on the findings of this study, the following recommendations were made:

1. Teachers should consider the use of graphic organizers for the teaching of organic chemistry.
2. Classroom teachers' use of graphic organizers should be encouraged and supported in organic chemistry classes irrespective of students' gender and cognitive styles.
3. Students should also adopt the use of graphic organizers as study tools to improve their achievement in chemistry.
4. Curriculum developers should include the use of graphic organizers as one of the strategies that can be employed in implementing the chemistry curriculum.
5. Textbook authors should also consider the use of graphic organizer in the presentation of information in chemistry textbooks.
6. Research unit in ministries of education should conduct seminars and workshop to train teachers on the use of graphic organizers in teaching chemistry.

7. Teacher educators should also consider the exposure of pre-service teachers to graphic organizers as one of the tools that can be used to assist students to learn chemistry.

Suggestion for Further Studies

Further studies can be conducted in the following areas:

1. A similar study can be conducted using other forms of graphic organizer such as spider maps, fish bone, e.t.c to investigate students' achievement in organic chemistry.
2. Future research can adopt the use of one on one interview (clinical interview) rather than focus group that was used in this study.
3. Researchers can consider replicating a similar study for investigating other perceived difficult topics in chemistry
4. Similar study can also be conducted in other geographical areas for the purpose of generalizing the findings of this study.

REFERENCES

- Ababio, O. Y. (2013). *New school chemistry for senior secondary schools*. Revised by L. E. S. Akpanisi & H. Igwe (6th Ed.). Africana first publishers Plc: Onitsha.
- Abimbola, I. O. (2013). The misunderstood word in science: Towards a technology of perfect understanding for all. *The One Hundred and Twenty Third (123rd) Inaugural Lecture*. Ilorin: Unilorin Press.
- Academic Press Dictionary of Science and Technology. *Definition of science*. Retrieved on February, 18th 2017 from <https://gly.uga.edu/railsback/1122sciencedefinitions>
- Adcock, A., (2000). *Effects of cognitive load on processing and performance*. Retrieved from <http://aimlab.memphis.edu/amyscogpaper.pdf>
- Adesoji, F. A., & Kenni, A. M. (2013). Continuous assessment, mock results and gender as predictors of academic performance of chemistry students in WASSCE and NECO examinations in Ekiti State. *International Education Studies*, 6(7), 1-5.
- Adesoji, F. A & Olatubosun, S. (2008). Student, teacher and school environmental factors as determinants of achievement in senior secondary school in Oyo state, Nigeria. *The Journal of International and Social Research*, 1(2), 13- 34.
- Adetunji, A. A., Bamidele, E. F., & Awodele, B. A. (2013). Effects of historical simulations as narrative and graphic advance organizers on Nigerian junior secondary school students' learning outcomes in basic science. *Mediterranean Journal of Social Sciences*, 4(2), 743-752.

- Adodo, S. O. (2013). Effects of mind mapping as self regulated learning strategy in students' achievement in basic science and technology. *Mediterranean Journal of Social Sciences*, 4(6), 163-172
- Adu-Gyamfi, K. (2011). *Senior high school chemistry students' understanding of IUPAC nomenclature of organic compounds*. (M.Phil Thesis) University of Cape Coast.
- Adu-Gyamfi, K., Ampiah, J. G., Appiah, J. Y. (2013). Senior high school chemistry students' performance in IUPAC nomenclature of organic compounds. *Cypriot Journal of Educational Sciences*, 8(4), 472-483.
- Adu-Gyamfi, K., Ampiah, J. G., Appiah, J. Y. (2012). Senior high school chemistry students' difficulties in writing structural formulae of organic compounds from IUPAC names. *Journal of Science and Mathematics Education*, 6(1), 175-191.
- Agogo, P. O., & Onda, M. O. (2014). Identification of students' perceived difficult concepts in senior secondary school chemistry in Oju local government area of Benue state, Nigeria. *Global Educational Research Journal of Humanities, Social Sciences and Education*, 1(10), 88-93
- Akinbobola, A. O. (2015). Enhancing physics students' attitude through the use of pictorial, written and verbal advance organizers. *International Institute for Science and Technology Education*, 40, 35-40.
- Akinoglu, O., & Yasar, Z. (2007). The effect of note taking in science education through the mind mapping technique on students, attitudes, academic achievement and concept learning. *Journal of Baltic Education*, 6(3), 34-43.

- Akpokiere, R., (2015). *Development and evaluation of a computer instructional package on organic chemistry for colleges of education students in Nigeria*. Unpublished (Ph.D. Theses) University of Ilorin.
- Alberta (2002). *Instructional strategies. Health and life skills guide to implementation (k-9)* Pp 67-114. Retrieved on March, 24 2017 from www.pedagogy.merlot.org/teaching_strategies.html
- Altun, A., & Cakan, M. (2006). Undergraduate students' academic achievement, field dependent/independent cognitive styles and attitude toward computers. *Educational Technology & Society*, 9(1), 289-297.
- Anderson, J. R. (1998). *Schema theory of learning*. Retrieved from <http://www.ligulaLinksLibrary.SILinternationalCsus.edu>
- Anderson, J. (1990). *Cognitive Psychology and its Implications* (3rd ed.). New York: W. H. Freeman.
- Anderson, J. R. (1983). *The architecture of cognition*. Cambridge, MA: Harvard University Press.
- Anderson, L. W., & Krathwohl, D. R. (2001). *A taxonomy for learning, teaching and assessing: A revision of Bloom's taxonomy of educational objectives*. New York: Longman
- Anderson, R. C. & Pearson, P. D. (1984). A schema-theoretic view of basic process in reading comprehension. In P. D. Pearson (Ed.), *Handbook of reading research*, New York: Longman (Pp 255-291).

- Aniodoh, H. C., & Egbo, J. J. (2013). Effect of gender on students' achievement in chemistry using inquiry role instructional model. *Journal of Educational and Social Research*, 3(6), 17-21.
- Antoine, K. A. (2013). *The effect of graphic organizers on science education: Human body systems*. An (M. A. Theses) Louisiana State University.
- Ariaga, B. A & Nwanekezi, A. U. (2018). Concept mapping strategy and its effects on students' performance in organic chemistry in Imo state, Nigeria. *International Journal of Scientific Research in Education*, 11(4), 797-809
- Arokoyo, A. A., & Obunwo, J. C. (2014). Concept-mapping: an instructional strategy for retention of organic chemistry concepts. *International Journal of scientific Research and Innovative Technology*, 1(3), 56-61.
- Atkinson, R., & Shiffrin, R. (1968). Human memory: A Proposed System and its Control Processes. In K. W. Spence, & J. T. Spence, *The psychology of learning and motivation* (pp. 89-195). New York: New York: Academic Press.
- Ausubel, D. P. (2000). *The acquisition and retention of knowledge: A cognitive view*. Boston: Kluwer Academic Publishers.
- Ausubel, D. P. (1968). *Educational psychology*. A cognitive view. New York: Holt, Rinehart & Wiston.
- Ausubel, D. P. (1960). The use of advance organizers in learning and intention of meaningful material. *Journal of Educational Psychology*, 51, 267- 272.

- Ausubel, D. P., Novak, J. D., & Hanesian, H. (1978). *Educational Psychology: A cognitive view* (2nd Ed.). New York: Cambridge University Press.
- Aydin, G. (2015). The effects of technology supported mind and concept mapping on students' construction of science concepts. The effect of mind mapping in science education. *Anthropologist*. 20(1,2) 166-176
- Ayverdi, L., Nakiboglu, C. S., Aydin, O. Z. (2014). Usage of graphic organizer in science and technology lesson. *Procedia- Social and Behavioural Sciences*, 116, 4264-4269
- Baek, S. G, Choi, H. J. (2002). The relationship between students' perceptions of classroom environment and their academic achievement in Korea. *Asia Pacific Education Review*, 3, 125-135
- Balin, A. G. (2013). Use of Technology-assisted techniques of mind mapping and concept mapping in science education: A constructivist study. *Journal of Irish Educational Studies*, 32(4), 437-456.
- Bamidele, E. F., Adetunji, A. A., Awodele, B. A., & Irinoye, J. (2013). Attitudes of Nigerian secondary school chemistry students towards concept mapping strategies in learning the mole concept. *Academis Journal of Interdisciplinary Studies*, 2(2), 475-484.
- Bassey, S. W., Umoren, G. U., Udida, L. A. (2013). *Cognitive styles, secondary school students' attitude and performance in chemistry in Akwa-Ibom State, Nigeria*. Retrieved on 28th March, 2017 from <http://www.hbcse.res.in/episteme/episteme-e-proceedings/bassey.com>
- Baxendel, B. (2003). Consistent, coherent, creative: The 3Cs of graphic organizers. *Council for Exceptional children*, 36(3), 46-53.

- Ben-David, R. (2002). *Enhancing comprehension through graphic organizers*. Retrieved from [https://www.ERIC/RCS\(CS510775\)](https://www.ERIC/RCS(CS510775))
- Boujaoude, S., & Attieh, M. (2008). The effect of using concept maps as study tools on achievement in chemistry. *Eurasia Journal of Mathematics, Science and Technology Education*, 4(3), 233-246.
- Boundless (2016). *The effective teaching strategies*. Boundless education. Retrieved on 25th January, 2017 from <https://www.boundless.com/chemistry/textbooks/boundless-chemistry-textbook/working-with-students-4/teaching-strategies-21/effective-teaching-strategies-64-12994/>
- Boundless (2015). *The study of chemistry*. Boundless chemistry. Retrieved on 8th February, 2017 from <https://www.boundless.com/chemistry/textbooks/boundless-chemistry-textbook/introduction-to-chemistry-1/overview-of-chemistry-26/the-study-of-chemistry-176-7533/>
- Bradford, A. (2015). *What is science?* Retrieved on 3rd March, 2017 from <https://www.livescience.com>
- Braselton, S., & Decker, B. S. (1994). Using graphic organizers to improve the reading of mathematics. *The Reading Teacher*, 48(3), 276-281.
- Bruner, J. S. (1961). The act of discovery. *Harvard Educational Review*, 31(1), 21-32
- Buzan, T. (2000). *The mind map book*. Penguin Books.
- Cakan, M. (2000). Interaction between cognitive styles and assessment approaches

- Casteleyn, J., & Mottart, A. (2012). Presenting Material via graphic organizer. *Procedia- Social and Behavioral Sciences*, 69, 458-466.
- Castillo-Montoya, M. (2016). Preparing for interview research: The interview protocol refinement framework. *The Qualitative Report*, 21(5), 811-831.
- Chabari, K. K., Wachanga, S. W., & Anditi, Z. O. (2018). Effects of graphic organizers experiential teaching approach on secondary school students' achievement in chemistry in Nakuru North Sub-County, Kenya. *Journal of Humanities and Social Science*, 23(2), 79-91.
- Chang, K., Sung, Y., & Chen, I. (2002). The effect of concept mapping to enhance text comprehension and summarization. *Journal of Experimental Education*, 71 (1), 5-23.
- Chawla, J. (2015). Effect of concept mapping strategy on achievement in chemistry of six graders in relation to gender. *International Journal of Science and Research*, 4(12), 531-536.
- Chawla, J., & Singh, G. (2015). Effect of concept mapping strategy on achievement in chemistry among IX grader girls. *International Journal of Informative & Futuristic Research*, 3(3), 1036-1044.
- Cheema, A. B., & Mirza, M. S. (2013). Effect of concept mapping on students' academic achievement. *Journal of Research and Reflections in Education*, 7(2), 125-132.
- Chief Examiners' Report (2017). The West Africa Senior Secondary School Certificate Examinations. Retrieved on 12th August, 2018 from www.waeheadquartersgh.org/intex.php

Chief Examiners' Report (2016). The West Africa Senior Secondary School Certificate Examinations. Retrieved on 12th August, 2018 from www.waeheadquatersgh.org/intex.php

Chief Examiners' Report (2015). The West Africa Senior Secondary School Certificate Examinations. Retrieved on 12th August, 2018 from www.waeheadquatersgh.org/intex.php

Chief Examiners' Report (2012). The West Africa Senior Secondary School Certificate Examinations. Retrieved on 12th August, 2018 from www.waeheadquatersgh.org/intex.php

Ching, L., & Chee, T. (2010). Scaffolding writing using feedback in students' graphic organizer: Novice writers' relevance of idea and cognitive load. *Educational Media International*, 47(2), 135-152.

Clark, J. (2002). *The names of organic compounds*. Retrieved on October, 14th 2010 from <http://www.chemguide.co.uk/basicorg/conventions/names.html>

Clayden, J., Greeves, N., & Warren, S. (2012). *Organic chemistry (2nd Ed.)*. New York: Oxford University Press

Cooper, G. (1998). *Research into cognitive load theory and instructional design at UNSW*. Retrieved from <http://www.wayback.archive.org/web/2007080131437/http://education.arts.unsw.edu.au/staff/sweller/clt/index.html>

- Curzon, L. B. (1990). *Teaching in Further Education*. An outline of principles and practice (4th Ed.). Cassel Education Ltd: London.
- Daniels, H. L. (1996). *Interaction of cognitive style and learners control of presentation mode in hypermedia environment*. Retrieved from <http://www.scholar.lib.vt.edu/theses/available/etd-3132141279612241/>
- Davis, M. (2010). *Concept mapping, Mind mapping and Argument mapping. What are the differences and do they matter?* Retrieved from http://www.academia.edu/448864/Mind_Mapping_Concept_Mapping_Argument_Mapping_What_are_the_differences_and_Do_they_Matter.html
- De-Gale, S., & Boisselle, L. N. (2015). The effect of POGIL on Academic Performance and Academic Confidence. *Science Education International*, 26(1), 56-61.
- Demide, C. O. (2000). *Enhancing the transition from concrete to formal cognitive level achievement in chemistry*. An Unpublished (M.Ed. Project) Tafawa Balewa University, Bauchi.
- Dettrue, M. (2004). Cognitive style and self efficacy. *The American Journal of Distance Education* 18(1), 21-38.
- Dewey, J. (1929). *The quest for certainty*. New York: Minto
- DiCecco, V. M., & Gleason, M. M. (2002). Using graphic organizers to attain relational knowledge from expository text. *Journal of Learning Disabilities*, 34.

- Diekhoff, G. M. (1983). Relationship judgments in the evaluation of structural understanding. *Journal of Psychology*, 75(1), 227-233.
- Duffill, N. (2013). *Choosing and using mind maps and concept maps. A short conversation for mind mappers*. Harport consulting retrieved on August 18th 2017 from www.olympic-limited.co.uk
- Dye, G. A. (2000). Graphic organizers to the rescue! Helping students link and remember information. *Teaching Exceptional Children*, 32(2), 72-76.
- Edomwonyi-Out, L., & Avaa, A. (2011). The challenge of effective teaching of chemistry: A case study. *Leonardo Electronic Journal of Practices and Technologies*, 18, 1-8
- Eisner, E. W., (2002). *The educational imagination*. Upper Saddle River, NJ: Merrill Prentice Hall
- Ekenobi, T. N., & Mumuni, A. A. (2015). Efficacy of advance organizers strategies on chemistry students' cognitive achievements in redox reaction concept. *British Journal of Psychology Research*, 3(5), 16-27.
- Ekenobi, T. N., Mumuni, A. A. O., Nwanekezi, A. U. (2016). Enhancing chemistry students' retention of redox reaction concepts through intervention with advance organizer. *British Journal of Psychology Research*, 4(4), 34-46.
- Ella, B. O. (2014). *Cognitive styles and attitude to science of senior secondary school science students of different cognitive ability levels*. Published (M. Ed. Project) University of Nigeria, Nsukka.
- Ellis, E. (2004). *What's the big deal about GO?* retrieved from <http://graphicorganizer.com>

- Ellis, E., & Howard, P. (2005). *Graphic organizers: powerful tools fot teaching students with learning disabilities*. Retrieved from <https://www.GraphicOrganizers.com>
- Entwistle, N., McCune, V., & Hounsell, J. (2002). *Approaches to Studying and Perceptions of University Teaching-Learning Environments: Concepts, Measures and Preliminary Findings*. University of Edinburgh, UK. Enhancing Teaching and Learning Environments in Undergraduate Courses Project
- etsu.edu (2017). *schema theory*. Retrievedon June 4th 2017 from <https://www.etsu.edu/fsi/learning/schematheory.aspx>
- Eya, N. M. & Ezeh, D. N. (2020). Meta-analysis of influence of gender on students' academic achievement in chemistry in Nigeria. *J. Chem. Soc.*, 45(4), 615-619.
- Ezendu, F. O., & Obi, T. N. (2013). Effect of gender and school location on students' achievement in chemistry in secondary schools in Nsukka local government area of Enugu State, Nigeria. *Research on Humanities and Social Sciences*, 3(15), 50-55.
- Frey, C. (2016). *Concept maps Vs mind maps*. Retrieved on 7th February, 2017 from <http://www.mindmappingsoftwareblog.com/concept-maps-vs-mind-maps/>
- Friedl, S., (2016). *What is chemistry?* retrieved on 16th March, 2017 from <http://www.study.com/academy/lesson/what-is-chemistry-definition-history-branches.html>
- Gagic, Z. Z., Skuban, S. J., Radulovic, B. N., Stojanovic, M. M., and Gajic, O. (2019). The implementation of mind maps in teaching physics . Educational efficiency and students' involvement. *Journal of Baltic Science Education*, 18(1), 117-131.

- Gajria, M. Jitenda, A. K., Sood, S., & Sacks, G. (2007). Improving comprehension of expository text in students with learning disabilities: A research synthesis. *Journal of Learning Disabilities, 40*, 210-255
- Gil-Garcia, A., & Villegas, J. (2003). *Engaging minds, Enhancing comprehension and constructing knowledge through visual representation*. A paper presented at Word Association for Case Method Research and Application Conference. France (June, 29th-July, 2nd).
- Gillette, M. L. (2004). *Introducing IUPAC nomenclature for organic chemical compounds*. Retrieved from <http://www.cerlabs.com/experiments/1053447599X.pdf>
- Goddard, L., Pring, L., & Felminghan, N. (2005). The effects of cue modality on the quality of personal memories retrieved. *Memory, 13*(1), 79-86.
- Gongden, E. J., Delmang, T. K. (2016). The efficacy of concept mapping instructional strategy in remedying students' problem-solving difficulties in stoichiometry. *African Research Review, 10*(2), 144-157
- Goodnough, K., & Woods, R. (2002). *Student and Teacher Perceptions of Mind Mapping: A Middle School Case Study*. A paper presented at Annual Meeting of American Educational Research Association, New Orleans (1st to 5th April, 2002)
- Guastello, E. F., Beasley, T. M., & Sinatra, R. C. (2000). Concept mapping effects on science content comprehension of low- achieving inner-city seventh graders. *Remedial and Special Education, 20*(6), 356-364.

- Hendron, J. (2003). *Advance and graphical organizers: Proven strategies enhanced through technology*. Retrieved on June, 6th 2017 from www.glnd.k12.va.us/resources/graphicalorganizers
- Howard, S. (n.d). *cognitive load theory (John Sweller)* Retrieved on May, 19th 2017 from <http://www.instructionaldesign.org/theories/cognitive-load.html>
- Idika, M. I. (2017). Influence of cognitive style and gender on secondary school students' achievement in and attitude to chemistry. *Advances in Social Sciences Research Journal*, 4(1), 129-139.
- Iloputaife, E. C. (2012). Science education for technological attainment in Nigeria: In search of facilitators and pedagogical solution. *The Seventeenth Inaugural Lecture*. Enugu: University of Nigeria Press
- Jonassen, D. H., & Grabowski, B. I. (1993). *Handbook of individual differences. Learning and instruction*. Hillsdale. NJ: Lawrence Erlbaum.
- Kalyanasundaram, M., Abraham, S. B., Ramachandran, D., Jayaseelan, V., Bazroy, J., Singh, Z., & Purty, A. J. (2017). Effectiveness of mind mapping technique in information retrieval among medical college students in Puducherry- A pilot study. *Indian Journal of Community Medicine*, 42(1), 19-23.
- Kang, S. (2004). Using visual organizers to enhance EFL instruction. *ELT Journal*, 58 (1), 58-67.
- Katayama, A. D., Robinson, D. H., Devaney, T., & Dubois, N. F. (1997). *The interaction of study materials and spaced review on transfer and relational learning (microform)*. Retrieved from <http://www.eric.ed.gov/contentdelivery/servlet/ERICServlet?accno=ED411280>

- Keter, J. K., Wachanga, S. W., & Anditi, Z. O. (2016). Effect of gender on motivation in chemistry lessons when students are taught through computer based mastery learning (CBCML) in Bomet County, Kenya. *Journal of Educational Policy and Entrepreneurial Research*, 3(11), 24-35.
- Khalaji, H. R. (2016). The effect of graphic organizers on students' writings: The case of EFL students, Islamic Azad University, Malayer Branch. *International Journal of Educational Investigations*. 3(3), 94-105
- Khandagale, V. S. (2016). A study of cognitive style among teacher educators. *International Journal of Arts, Humanities and Management*, 2(3), 12--20.
- Kinniburg, L., & Shaw, E. (2007). Building fluency in elementary science through readers theatre. *Science Activities*, 44, 16-22
- Kuldeep, S. K., & Meera, T. (2016). Cognitive Styles of secondary school teachers. *International Journal of Advanced Research in Education & Technology*, 3(4), 147-150.
- Langford, D. (2014). The use of concept mapping to enhance the teaching of chemical equilibrium in a Grade 12 physical science tutoring classroom. A published M. Ed. Thesis of Cape Peninsula University of Technology.
- Lok, W. F. (2014). The effect of concept mapping in learning physical chemistry among students of Perakmatriculation college. In J. T. Leach, N. J. Ahmad & S. Tahir (Eds.) *Learning science and mathematics in the classroom: Case studies of successful practices*. Pp. 78-88. Penang, Malaysia: SEAMEO RECSAM.

- Longanathan, M. (2010). Concept map vs mind map. Retrieved on June 12th 2017 from <http://cognitivenoise.wordpress.com/april2010>
- Lucas, B. (2001). Creative teaching, teaching creativity and creative learning. In A. Craft, B. Jeffrey, & M. Leibling (Eds.), *Creativity in education*. London: Continuum
- Mani, A. (2012). Effectiveness of concept mapping and mind mapping in science teaching. *TechnoLEARN*. 2(1) 77-82
- Manoli, P., & Papadopoulou, M. (2012). Graphic organizers as a reading strategy: Research findings and issues. *Creative Education*, 3(3), 348-356.
- Marzano, R. J., Pickering, D. J., & Pollock, J. E. (2001). *Classroom instruction that works. Research-based strategiesb for increasing student achievement*. Alexandria: Alexandria, VA: Association for Supervision and Curriculum Development.
- Masterminds (2001) Using graphic organizers to make sense of the curriculum. Retrieved on March, 24th 2017 from <http://www.calhoun.k12.al.us/makessense.com>
- Mayer, R. (2003). *Learning and Instruction*. Pearson Education Inc: New Jersey, USA.
- Mayer, R. E. (1979). Can advanced organizers influence meaningful learning? *Review of Educational Research*, 49, 371-383
- McElory, L. T. & Coughlin, C. N. (2009). *The other side of the story: using graphic organizer as cognitive learning tools to teach students to construct effective counter- analysis*. Unpublished (Ph.D. Thesis) University of Baltimore

- Meera, K. P., & Aiswarya, K. S. (2015). A study on the effectiveness of graphic organizers in college students' english vocabulary building
- Mehrotra, P. N. (2008). Manual of mixed type group test of intelligence (MGTI). Agra: National Psychological Corporation.
- Merchant, G. J., Paulison, S. E. & Rothlisberg, B. A. (2001). Relations of middle school students' perception of family and school contexts with academic achievement. *Psychology in the Schools*, 38(6), 505-519.
- Meyen, E. L., Vergason, G. A. & Whelan, R. J. (1996). *Strategies teaching exceptional children in inclusive settings*. Denver: Love Pub. Co.
- Miller, G. A. (1956). The magical number seven, plus or minus two: some limits on our capacity to process information. *Psychological Review*, 63(2), 81-97.
- Miller, S. (2011). *Using graphic organizer to increase writing performance*. Unpublished (M. A. Theses) State University of New York, Fredonia.
- Mindtools. (2017). *cognitive load theory*. Retrieved from mindtools: <https://www.mindtools.com/pages/article/cognitive-load-theory.html>
- Musya, M. N. (2015). *Cognitive styles and academic achievement among secondary school learners in Kenya*. (M. Ed. Theses) University of Nairobi.
- NERDC. (2008). *Chemistry for senior secondary school*. Lagos: NERDC Printing Press.

- NeSmith, R. A. (2003). *Students' and teachers' perceptions of effective teaching and learning in the middle level science classroom: The effects on students achievement*. A published Ph. D. thesis submitted to Curtin University of Technology.
- Novak, J. D., & Gowin, D. B. (1984). *Learning How to Learn*. New York: Cambridge University Press.
- Nozari, A. Y. & Siaman, H. (2015). the relationship between field dependent - independent cognitive style and understanding of English text reading and academic success. *Materia Socio Medica*, 27(1), 39-41
- Ogan, R., (2012). *Influence of cognitive styles, and gender on students' achievement in selected area of mathematics*. (M. Ed. Project) University of Nigeria, Nsukka.
- Ogbonna, E. C. (2014). *Effects of concept mapping on students' achievement and interest in selected concepts from organic chemistry*. An (M.Ed. Project) University of Nigeria, Nsukka
- Okanlawon, A. E. (2016). A comparative analysis of cognitive complexity of Nigerian senior school certificate chemistry examination questions constructed by two examination bodies. *Research on Humanities and Social Sciences*, 6(2), 38-50
- Okeke, E. A. C. (2001). Women in science, technology and mathematics education in Nigeria. *42nd annual conference proceedings of Science Teachers Association of Nigeria (STAN)*. Ibadan: A STAN Publication (Pp3-11).

- Okeke, O. J. (2011). *Effect of mind mapping teaching strategy on students' achievement, interest and retention in secondary school chemistry*. Published (Ph.D. Thesis) University of Nigeria, Nsukka.
- Okereke, C. (2011). Influence of gender, school location and the use of play-way simulation on school achievement in chemistry. *Journal of Research in National Development*, 9(1), 381-387.
- Okoronka, U. A., & Wada, B. Z. (2014). Effects of analogy instructional strategy, cognitive style and gender on senior secondary school students achievement in some physics concepts in Mubi Metropolis, Nigeria. *American Journal of Educational Research*. 2(9), 788-792
- Olorundare, A. S. (2014). *Theory into Practice: Beyond the Surface Curriculum in Science Education*. Ilorin : Unilorin Press.
- Oloyede, O. I. (2011). A meta-analysis of effects of the advance organizer in acknowledgement and retention of senior secondary school (SSS) chemistry. *International Journal of Education Science*, 3(2), 129-135.
- Oloyede, O. I. (2010). Comparative effect of the guided discovery and concept mapping teaching strategies on SSS students' chemistry achievement. *Humanities and Social Sciences Journal*, 5(1), 1-6.
- Omorogbe, E., & Ewansiha, J. C. (2013). The Challenge of Effective Science Teaching in Nigerian Secondary Schools. *Academic urnal of Interdisciplinary Studies*, 181-188.

- Onyekuru, U. O. (2015). Field dependence- field independence cognitive style, gender, career choice and academic achievement of secondary school students in Emohua local government area of rivers state. *Journal of Education and Practice*, 6(10), 76-85.
- Opara, J. A., (2015). Gender and science education in Nigeria. *International Journal of English and Education*. 4(3), 152- 159.
- Osuolale, O. J. (2014). Problems of teaching and learning of science in junior secondary schools in Nasarawa state, Nigeria. *Journal of Education and Practice*, 5(34), 109- 119
- Otor, E. E. (2013). Effects of concept mapping strategy on students' achievement in difficult chemistry. *Educational Research*, 4(2), 182-189.
- Owolabi, J., & Adaramati, T. F. (2015). Effects of graphic organizer on students' achievement in algebraic word problems. *Journal of Education and Practice*, 6(5) 39-44.
- Paivio, A. (1986). *Mental representations: A dual coding approach*. New York: Oxford University Press
- Parikh, I. N. (2016). Effectiveness of teaching through mind mapping technique. *The International Journal of Indian Psychology*, 3(3), 148-156.
- Piaget, J. (1980). *The Psychogenesis of Knowledge and its epistemological significance*. In M. Piatelli-Palmarini (Ed.), *Language Learning*. Cambridge, M. A: Harvard University Press (Pp 23-34)

- Popoola, R. A., & Olorundare, A. S. (2017). The use of problem-based instruction strategy (PBIS) in gas laws class: A gender academic performance difference. *International Journal of Trend in Scientific Research and Development*, 1(4), 458-464.
- Praveen, K. J. (2001). *Cognitive styles inventory*. Rakhi Prakashan: Agra.
- Rahmad, F. (2019). Students' perception on the use of mind mapping application software in learning writing. *CELTIC*, 6(1), 58-64
- Ramlah, B.J. (2014). Relationship between students' cognitive style (field dependent and field independent) with their mathematics achievement in primary school. *International Journal of Humanities, Social Sciences and Education*, 1(10), 88-93
- Ravindranath, S., Abrew, W. K., & Nadarajah (2016). Students' perception of mind mapping in problem based learning. *Journal of Contemporary Medical Education*, 4(2), 60-66
- Ritchie, D., & Gimenez, F. (1995). Effectiveness of graphic organizers in computer-based instruction with dominant spanish-speaking and English-speaking students. *Journal of Research on Computing in Education*, 28, 221-233.
- Sara, S. S., Maruta, A. G., & Olarinoye, R. D. (2016). Effects of cognitive style on academic performance of senior secondary school biology students in process skills in Jigawa State, Nigeria. *International Journal of Educational Benchmark*, 4(3), 66-72.
- Savery, J. R. & Duffy, T. M. (2001). *Problem Based Learning: An instructional model and its constructivist framework*. Center for Research on Learning and Technology (CRLT). Technical Report No. 16-01

Sciencecouncil.org/about-us/our definition of science/2017. *Definition of science*. Retrieved July 20th 2017

Sciencelearn.org (2017). *Reasons for teaching the nature of science*. Retrieved on 1/19/2018 from <https://www.legacy.sciencelearn.org.nz/Nature-ofscience/Reasons-for-teaching-the-nature-of-science>

Shodeinde, A. O., (2013). *Effects of cognitive mind mapping on the achievement of electrical and electronic trades students in technical colleges in Ogun state*. Published (M.Ed. Project) University of Nigeria, Nsukka.

Singh, I. S., & Moono, K. (2015). The effect of concept maps on student achievement in selected topics in chemistry at tertiary levve. *Journal of Education and Practicr*, 6(15), 106-116.

Singh, K. A., & Kaur, J. (2004). The effects of mind mapping strategies on the development of writing skills of selected from three students. *Universiti Putra Malaysia Institutional Repository (UPMIR)*.

Sirhan, G. (2007). Learning difficulties in chemistry: An overview. *Journal of Turkish Science*

Slavin, R. E. (1991). *Educational Psychology*. Needham Heights: MA: Ally & Bacon.

Sternberg, R. J. (2006). *Cognitive Psychology* (fourth ed.). Wadsworth: Thompson Wadsworth.

Struble, J. (2007). Using graphic organizer as formative assessment. *Science Scope*, 69-71

Stull, A. T., Mayer, R. E., (2007). Learning by doing versus learning by viewing: Three experimental comparisons of learner- generated and author- provided graphic organizers. *Journal of Education Psychology*, 99(4), 808- 820.

- Suderman, P., Setyosari, P., Kuswandi, D., & Dwiyoogo, D. W. (2016). The effect of learning strategy and cognitive style toward mathematical problem solving learning outcomes. *Journal of Research and Method in Education*, 6(3), 137-143.
- Supasorn, S., Kamsai, L., & Promarak, V. (2014). Enhancement of learning achievement of organic chemistry using inquiry- based semi- small scaleexperiments. *Procedia Social and Behavioural Sciences*, 769-774.
- Sweller, J. (1988). Cognitive load during problem solving: Effects on learning. *Cognitive Science*, 12, 257-285
- Taber, K. S. (2002). *Alternative conceptions in chemistry: Prevention , diagnosis and cure*. London : The Royal Society of Chemistry
- Talbert, L. E., Bonner, J., Mortezaei, K., Guregyan, C., Henbest, G., & Eichler, J. F. (2020). Revisiting the use of concept maps in a large enrollment general chemistry course: implementation and assessment. *Chemistry Education Research and Practice*, 21, 37-50.
- Torres, M. O., Espana, R. C., & Orleans, A. V. (2014). Integrating graphic organizers in facilitating learning chemistry. *International Journal of Educational Studies*, 1(1), 1-8.
- Trehan, D. M. (2015). *The impact of concept mapping as a learning tool on students' perception of and experiences with introductory statistics*. Published Ph. D. Dissertation submitted to The Kent State University.
- Udo, N. N., & Ubana, U. A. (2013). Teaching physics for retention. *International Journal of Modern Management Sciences*, 2(1), 18-25.

- Udosoro, U. J. (2011). The effects of gender and mathematics ability on academic performance of students in chemistry. *International Multidisciplinary Journal, Ethiopia*, 5(4), 201-213.
- Umoh, C. G. (2003). A theoretical analysis of the effects of gender and family on human resource development. *Journal of Curriculum organisation of Nigeria*, 10(1), 1-4.
- Upahi, J. E., Isreal, D. O., & Olorundare, A. S. (2016). Analysis of the West African senior school certificate examination chemistry questions according to Bloom's revised taxonomy. *Eurasian Journal of Physics and Chemistry Education*, 8(2), 59-70
- Vidyanand, S. K., (2016). A study of cognitive style among teacher educators. *International Journal of Arts, Humanities and Management Studies*. 2(3), 12-13
- Vygotsky, L. (1962). *Thought and Language*. Cambridge, M. A: The M. I. T. Press
- Wachanga, S. W., Arimba, A. M., & Mbugua, Z. K. (2013). Effects of advance organizer teaching approach on secondary school students' achievement in chemistry in Maara District, Kenya. *International Journal of Social Science & Interdisciplinary Research*, 2(6), 24-36.
- WAEC Syllabus (2017). Regulations and draft syllabuses for the West African senior school certificate examination.
- Wang, Z., Adesope, O., Sundararajan, N., Buckley, P. (2021). Effects of different concept map activities on chemistry learning. *International Journal of Experimental Psychology*, 41(2), 245-260.
- Weinstein, C. E., & Mayer, R. E. (1986). The teaching of learning strategies. In M. C. Wittrock (Ed.), *Handbook of research on teaching*. New York: Macmillan

- Weisberg, M., Needham, P., & Hendry, R. (2016). "Philosophy of Chemistry", *The Stanford Encyclopedia of Philosophy (Winter 2016 Ed.)*, Edward, N. Z. (Ed.). Retrieved March, 20 2017 from <https://plato.stanford.edu/archives/win2016/entries/chemistry>
- Wills, S., & Ellis, E. (2008). *The Theoretical and Empirical Basis for Graphic Organizer Instruction*. Alabama: University of Alabama.
- Witkin, H. A., Oltman, P. K., Raskin, E., & Karp, S. A. (1971). *A manual of the group embedded figures test*. California: Consulting Psychologists Press.
- Woldeamanuel, M. M., Atagana, H., & Engida, T. (2014). what makes chemistry difficult? *AJCE*, 4(2), 31-43.
- Wolfe, P. (2001). *Brain matters: Translating research into classroom practice*. Alexandria, VA: Association for supervision and curriculum development.
- Wong, R. M., Sundararajan, N., Adesope, O. O., & Nishida, K. R. A. (2021). Static and interactive concept maps for chemistry learning. *International Journal of Experimental Psychology*, 41(2), 206-223.
- Woolfolk, A. (2001). *Educational Psychology (8th Ed.)*. Allyn and Bacon: Boston, USA.
- Wyss, R. (2002). *Field independent/ field dependent learning styles and L2 acquisition*.
- Yilmazel-Sahin, Y. (2007). Teacher education students' perception of use of MS Power point and value of accompanying handouts. Published Ph.D. Theses, University of Maryland
- Yunus, M. M., & Chien, C. H. (2016). The use of mind mapping strategy in malaysian university english test writting. *Creative Education*, 7(1), 619-626.

Zaini, S. H., Mokhtar, S. Z., & Nawawi, M. (2010). Effects of graphic organizer on students' learning in school. *Malaysian Journal of Educational Technology*. 10(1), 17-23.

APPENDIX I

UNIVERSITY OF ILORIN, ILORIN, NIGERIA
FACULTY OF EDUCATION
DEPARTMENT OF SCIENCE EDUCATION
INFORMED CONSENT FORM

Dear Respondent,

This is to inform you that your consent is required to participate in a research study. Detailed information about the research is stated below. Kindly endorse the consent form in recognition of your volunteer to participate in the study after reading about the research.

Purpose of the Research: The purpose of the research is to investigate the comparative effectiveness of concept and mind map organizers on senior secondary school students' performance in hydrocarbons as efforts to improve students' performance in organic chemistry and other related topics in chemistry.

Procedure: student participants are required to attend lesson on hydrocarbons for a period of two weeks that will be taught by your teacher who serve as a research assistant. The lesson will take place at the regular period for chemistry on the school time table. You will be required to write a test after participating in the lesson. The completed test items will be returned to the researcher to ascertain the effectiveness of the teaching method utilized by the instructor.

Confidentiality: You are assured that all information provided by you will be used for the purpose of this research and therefore will be treated with utmost confidentiality

Risks: The teaching and learning of the chemistry topics will be done at regular class periods without disrupting the regular class activities. Hence, no risk is envisaged for you as a participant in the research.

Benefits: The benefit of your participation in this research includes meaningful learning of hydrocarbons that are perquisite to understanding other organic chemistry concepts. Hence, improving your understanding of chemistry and recording good grades in external examinations.

Rights of Volunteers (Student Participants): Please be informed that your participation in this research is voluntary. Therefore, you may decide not to take part or withdraw your participation at any point in the research. If you require more information about the research, you may contact the Department of Science Education, University of Ilorin or call the researcher on phone number 08052348398.

Student Respondent Agreement: I hereby voluntarily consent to participate in the research. I am aware that I may decide not to participate or stop my participation at any stage in the research. Also, I understand that if I have questions about the research or my right as a participant, I may contact the Department of Science Education, University of Ilorin or the researcher on the phone number 08052348398.

.....		
Student Participant	Signature	Date

.....		
Student's Guardian	Signature	Date

.....		
Researcher	Signature	Date

APPENDIX II

INSTRUCTOR'S LESSON PLANS

The following lesson plans are developed to implement the effect of the use of graphic organizer to teach hydrocarbons to SS2 students. There are two experimental groups: one will be provided with concept map organizer while the other will be provided with mind map organizer. The control group will not be provided with any of these maps but will be taught the same concept as contained in the lesson plans.

Lesson 1

Name: IMAM, Bashirat Titilope

Matriculation Number:04/250C038

School:

Class:S. S. 2

Average Age of Students:16 Years

Subject: Chemistry

Topic: Hydrocarbons

Duration:40 minutes

Date:

Instructional Materials: Ball, plastic bags, nomenclature charts, and an organizer on hydrocarbons.

Behavioural Objectives: At the end of the lesson, students should be able to;

- i. Explain the meaning and sources of hydrocarbon
- ii. State the various classes of hydrocarbon citing examples
- iii. Discuss the bond type in the various classes of hydrocarbon
- iv. Enumerate the five characteristics of homologous series
- v. Explain the alkyl and functional groups citing examples

Entry Behaviour: Students' are familiar with carbon and its compound; the physical and chemical properties of carbon, and the allotropes of carbon

Introduction (3 minutes): the teacher introduces the lesson by reminding students of the position of carbon on the periodic table with emphasis on the valency of carbon, the properties of carbon and the allotropes of carbon. The teacher remarks that the day's lesson is hydrocarbon which is an example of organic compound. The teacher refers to the prior knowledge in the organizer that has been given to the students before the lesson. The ball, plastic bags are shown to students as products of organic compounds.

Presentation (25 minutes):

Step 1 (5 minutes): The teacher presents the lesson by explaining the meaning of hydrocarbons as organic compounds that contains carbon and hydrogen only and the sources of hydrocarbons. The teacher further explains to students that carbon is tetravalent and has the ability to undergo catenation by citing examples involving methane and propane. The teacher asks the students to predict why carbon has four covalent bonds (they should recall that the four valence electrons of carbon will form four bonds). The teacher explains that carbon atom forms covalent bond with four hydrogen atoms to form methane.

Step 2 (6 minutes): the teacher poses the question “do you think that a carbon atom can share more than one electron with another element?” then the teacher explains that carbon can form double and triple bond with hydrogen atoms to form homologous series of the alkene and alkynes. At this point the teacher refers students to the nomenclature charts. Identify the type of bond a carbon atom possesses and what the different bond looks like when examining the structure of a hydrocarbon.

Step 3 (10 minutes): the teacher explains the classes of hydrocarbons that it includes the aliphatic and aromatic hydrocarbon. She further explains by referring to the concept maps that the aliphatic

hydrocarbons include the saturated hydrocarbons {which have single bond in their structures - alkanes (*paraffins*)} and unsaturated hydrocarbons that have double and triple bonds {it include alkenes and alkynes respectively- olefins}. Also included in the aliphatic hydrocarbons are the cyclic compounds that are derivatives of the saturated and unsaturated hydro carbons. They include cycloalkanes, cycloalkenes and cycloalknes. The aromatic hydrocarbons are cyclic compounds that posses the ring structure of benzene and resemble benzene in their chemical behaviour. They include compounds like phenol, toluene e.t.c.

Step 4 (4 minutes): the teacher proceeds by asking questions from the students based on the discussion in step 3 and correct any misconception. The teacher further explains the meaning of homologous series citing relevant examples and the characteristics of homologous series. Emphasis is placed on characteristics such as; the general molecular formulae, differences between each successive homologues, physical and chemical properties and their methods of preparation. Also, the teacher explains the meaning of alkyl groups and functional groups by including relevant examples. Also, these characteristics are explained by making reference to the concept maps developed for the lesson.

Recapitulation (3 minutes): The teacher does a recap of the lesson by going over the major points of the lesson. Such points include the meaning and sources of hydrocarbon, the classes of hydrocarbon stating examples, the meaning and characteristics of homologous series, and the meaning of alkyl and functional groups citing examples. The teacher constructs a map with the students on the just concluded topic.

Evaluation (5 minutes): The teacher evaluates the lesson by asking questions such as;

- i. Explain the meaning and sources of hydrocarbon

- ii. State the various classes of hydrocarbon and cite relevant examples of each classes mentioned
- iii. Discuss the type of bonding in the various classes of hydrocarbon
- iv. Enumerate five characteristics of homologous series
- v. State what you understand by alkyl and functional groups

Summary and Conclusion (2 minutes): The teacher summarizes the lesson by correcting all misconceptions and buttressing some of the explanations given by the students during evaluation. The teacher further concludes the lesson by giving assignments to the students.

Assignments (2 minutes): The gives the students the following assignments;

- i. Construct a concept map showing the various classes of hydrocarbons
- ii. On the map indicate the position of the following; propene, ethane, cyclohexane, butyne and methylbenzene.
- iii. Write the first five members of each classes of the aliphatic hydrocarbons

References:

Ababio, O. Y. (2007). New school chemistry. African Publishers, Onitsha

Ohia, G. N. C., Amasiatu, G. I., Ajagbe, J. O., Ojokuku, G. O., & Mohammed, U. (2007). Comprehensive certificate chemistry. University Press (2nd Ed.), Ibadan.

Lesson 2

Name: IMAM, Bashirat Titilope

Matriculation Number: 04/250C038

School:

Class: S. S. 2

Average Age of Students: 16 Years

Subject: Chemistry

Topic: Nomenclatures and Isomerism in Organic Compounds

Duration: 40 minutes

Date:

Instructional Materials: yellow and blue colored foams, tooth picks, nomenclature charts, and concept maps OR mind map organizer on isomerism.

Behavioural Objectives: At the end of the lesson, students should be able to;

- i. State the first ten (10) members of an homologous series
- ii. Give IUPAC nomenclature of some organic compounds
- iii. State two major types of isomerism and give examples
- iv. Illustrate isomers of various organic compounds
- v. Draw relevant structures illustrating the geometric isomerism and give its nomenclature

Entry Behaviour: Students' have learnt the meaning of hydrocarbons and are familiar with structures of hydrocarbons.

Introduction (5 minutes): The teacher introduces the lesson by taking the students through the structures and formula of hydrocarbons (empirical, molecular and structural formula). The teacher further asks the students to state the first five members of the paraffins (alkanes) from their previous assignment. The teacher listens to the student and corrects all forms of mistakes and misconceptions. The teacher refers to the organizer that has been provided to the students before

the class. The formulae of some of the members of alkanes mentioned by the students will be illustrated by the teacher.

Presentation (30 minutes):

Step 1 (7 minutes): The teacher presents the lesson by stating the basic features of the IUPAC nomenclature of organic compounds by stating that it consists of a root, prefixes and suffixes using the developed concept maps. The teacher further explains that the root is generally the aliphatic hydrocarbon; the suffix is added to the root to indicate the presence of the principal substituent which is usually the principal functional group in the molecule. Compounds that belong to the same functional group bear the same suffix e.g; alkanes- ane; alkyne- yne; alkenes- ene. Prefixes are used to indicate the presence of a substituted alkyl or functional group other than the principal group. When more than one prefix of the same substituent group is present, prefixes such as, di- 2, tri- 3 and tetra- 4 are used. However, if there are different substituent groups, they are placed in alphabetical order.

Step 2 (10 minutes): the teacher hands out the nomenclature chart. Explain the nomenclature of various organic compounds identifying the type of bond and functional groups present in the structure of the organic compound. The teacher further explains the numbering of the carbon atoms in some selected structures and state the basic rules for naming of organic compounds and name some selected organic compounds in the nomenclature chart. The teacher hands over some colored foams and tooth picks to students to illustrate the isomers of hexane using the blue and yellow foam to represent carbon and hydrogen respectively while the tooth picks form the bond in the molecules

Step 4 (5 minutes): the teacher explains isomerism as a phenomenon that describes the existence of compounds with the same molecular formula but different structural formula (molecular

structure). The different structural formula is responsible for having compounds with the same molecular formula with different physical properties. Also, it is possible to have isomers that have the same molecular formula but belong to different homologous series (e.g ethanol and methoxymethane) thereby having different physical and chemical properties. The teacher explains further that as the number of carbon atoms increases, the number of isomers also increases.

Step 5 (8 minutes): the teacher explains the types of isomerism using the concept maps. The teacher states that they are structural and stereo isomerism. The teacher further explains the types of structural isomerism to include chain isomerism, positional isomerism and metamers (functional group isomerism). Also, the stereo isomerism includes the geometric and optical isomers. These isomers have same molecular formula but their structures occupy different position in space. The stereo isomers include the cis and trans isomers. It occurs due to the restrictive position of the C=C. However, the optical isomerism occurs when a compound has a chiral centre includes the dextro rotatory (d- or +) compounds and the laevo rotatory (L- or -) and they rotate plane polarized light.

Recapitulation (3 minutes): The teacher does a recap of the lesson by going over the major points of the lesson. Such points include going over the rules of naming organic compounds, stating the meaning of isomerism and the various types of isomerism. The teacher explains the steps in constructing their own maps.

Evaluation (5 minutes): The teacher evaluates the lesson by asking questions such as;

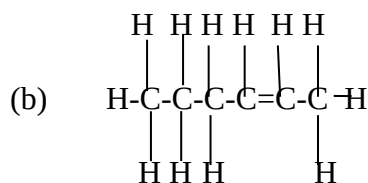
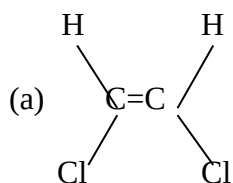
- i. State the first ten (10) members of alkane homologous series
- ii. Give IUPAC nomenclature of some organic compounds
- iii. State two major types of isomerism and give examples
- iv. Draw the isomers of octane

- v. Draw relevant structures illustrating the geometric isomerism and give its nomenclature

Summary and Conclusion (2 minutes): The teacher summarizes the lesson by correcting all misconceptions and naming some structures of organic compounds. The teacher concludes the lesson by presenting assignments.

Assignments (2 minutes): The gives the students the following assignments;

- i. Write the nomenclature of the following compounds;



- ii. Construct a concept map showing the classes and types of isomerism citing relevant examples.
- iii. Draw the possible isomers of hexane and name them
- iv. Draw the structure of the following compounds;

(a) 3-propyl hex-1-ene

(b) 2-methyl pent-2-ene

References:

Ababio, O. Y. (2007). New school chemistry. African Publishers, Onitsha

Ohia, G. N. C., Amasiatu, G. I., Ajagbe, J. O., Ojokuku, G. O., & Mohammed, U. (2007).

Comprehensive certificate chemistry. University Press (2nd Ed.), Ibadan.

Lesson 3

Name: IMAM, Bashirat Titilope

Matriculation Number: 04/250C038

School:

Class: S. S. 2

Average Age of Students: 16 Years

Subject: Chemistry

Topic: Alkanes and alkenes

Duration: 80 minutes

Date:

Instructional Materials: a chart showing the laboratory preparation of alkanes and alkenes.

Concept map OR mind map organizer on the chemistry of alkanes, alkenes and alkynes.

Behavioural Objectives: At the end of the lesson, students should be able to;

- i. Illustrate the laboratory preparation of methane and ethene
- ii. State the physical and chemical properties of methane and ethene
- iii. State the uses of methane and ethane
- iv. Describe a chemical test to distinguish between saturated (alkanes) and unsaturated compounds (alkenes)

Entry Behaviour: Students' are familiar with sources of hydrocarbons. Also, they have learnt the structures of alkanes and alkenes.

Introduction (6 minutes): The teacher introduces the lesson by stating the source of hydrocarbons. The teacher states the member of the alkane and alkene homologous series and their general molecular formula. The teacher does this by making reference to the organizer by identifying prior knowledge that are related to alkanes and alkenes

Presentation (53 minutes)

Step 1 (6 minutes): Methane (first member of the alkane series) is the simplest member of the alkane series with a molecular formulae CH_4 . They contain carbon and hydrogen only. They contain single bonds and have a general molecular formula of $\text{C}_n\text{H}_{2n+2}$. It is the major constituent of natural gas and is commonly referred to as marsh gas because it is given off from swamps. Other members of alkane include, ethane, propane, pentane e.t.c.

Step 2 (12 minutes): the teacher presents a chart that shows the laboratory preparation of methane. The teacher explains further by stating that methane is prepared by heating anhydrous sodium ethanoate with an alkali (soda lime). The anhydrous sodium ethanoate is grounded with equal mass of soda lime and heated in a glass tube to produce sodiumtrioxocarbonate IV and methane.

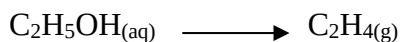


The methane given off can be collected over water. The delivery tube must be withdrawn from the water immediately after heating to avoid sucking back. Soda lime is preferred to caustic soda because it is not deliquescent and does not attack glass. Since, all members of a homologous series have similar methods of preparation, the teacher explains the preparation of methane and ask the students to state the method of preparation of ethane.

Step 3 (10 minutes): the teacher further explains the physical, chemical properties and uses of methane. Also, the teacher explains in detail the combustion and substitution reactions and uses of alkanes.

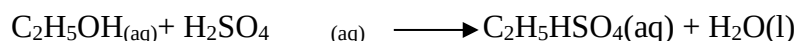
Step 4 (8 minutes): the teacher explains that the alkenes conform to the general molecular formula C_nH_{2n} . They are unsaturated hydrocarbons and contain $\text{C}=\text{C}$ in their structures. Ethene is the first and simplest member of the alkene series. It is one of the main products obtained during cracking of petroleum.

Step 5 (7 minutes): ethane is prepared in the laboratory by heating ethanol with excess H_2SO_4 at 170°C . The reaction involves the dehydration of ethanol by hot tetraoxosulphate (VI) acid.



The reaction occurs in two stages:

- i. Mixing ethanol and H_2SO_4 in volume ratio 1:2 to form ethyl hydrogentetraoxosulphate(VI).



- ii. The ethyl hydrogentetraoxosulphate(VI) formed decomposes on heating in the presence of excess H_2SO_4 to produce ethane.



Two volumes of concentrated $\text{H}_2\text{SO}_{4(\text{aq})}$ is added slowly to one volume of ethanol in a flat bottomed flask and shake gently to mix. The set up is shown in the chart on the board. The mixture is heated gently for a while till it attains a temperature of 170°C . The gas evolved is passed through concentrated sodium hydroxide to remove gaseous impurities such as carbon IV oxide, sulphur IV oxide and acid fumes. An empty conical flask is placed between the reaction mixtures to prevent sucking back. The ethane gas is collected over water.

Step 5 (10 minutes): the teacher explains the physical properties and the chemical properties of alkenes. Emphasis is placed on combustion, addition, polymerization reactions and uses of ethene. The teacher explains further the chemical test that distinguishes saturated from unsaturated hydrocarbons.

Recapitulation (4 minutes): The teacher does a recap of the lesson by going over the major points of the lesson. Such points include going over the laboratory preparation of alkanes and alkenes;

the major reaction they undergo; their uses and chemical test that differentiate between both. The students are taught how to develop their own maps.

Evaluation (8 minutes): The teacher evaluates the lesson by asking questions such as;

- i. With the aid of a chemical equation, illustrate the laboratory preparation of methane and ethene
- ii. State four physical and three chemical properties of methane and ethene
- iii. State three the uses of methane and ethane
- iv. Describe a chemical test to distinguish between alkanes and alkenes.

Summary and Conclusion (5 minutes): The teacher summarizes the lesson by correcting all misconceptions identified during evaluation. The teacher concludes the lesson by presenting assignments.

Assignments (4 minutes): The gives the students the following assignments;

Choose a member each from the alkane and alkene series and write the following:

- i. The molecular and structural formulae
- ii. The method of preparing them
- iii. Their physical and chemical properties
- iv. Their uses

References:

Ababio, O. Y. (2007). New school chemistry. African Publishers, Onitsha

Ohia, G. N. C., Amasiatu, G. I., Ajagbe, J. O., Ojokuku, G. O., & Mohammed, U. (2007). Comprehensive certificate chemistry. University Press (2nd Ed.), Ibadan.

Lesson 4

Name: IMAM, Bashirat Titilope

Matriculation Number: 04/250C038

School:

Class: S. S. 2

Average Age of Students: 16 Years

Subject: Chemistry

Topic: Alkynes and Aromatic hydrocarbons

Duration: 80 minutes

Date:

Instructional Materials: a chart showing the laboratory preparation of alkynes and alkenes.

Concept map OR mind map organizer on the chemistry of alkanes, alkenes and alkynes; and a concept OR mind map on aromatic hydrocarbons.

Behavioural Objectives: At the end of the lesson, students should be able to;

- i. Illustrate the laboratory preparation of ethyne
- ii. State the physical and chemical properties of ethyne
- iii. Describe a chemical test to distinguish between alkenes and alkynes
- iv. Draw the structure of benzene and state three derivatives of benzene
- v. State the uses ethyne and benzene

Entry Behaviour: Students' are familiar with sources of hydrocarbons. Also, they have learnt the structures of alkanes and alkenes.

Introduction (6 minutes): The teacher introduces the lesson by stating that alkynes conform to general molecular formulae C_nH_{2n-2} and shows a higher degree of unsaturation than alkenes. Ethyne is the simplest member of the alkyne series with a molecular formula C_2H_2 . The teacher relates the lesson to the chemistry of alkenes as a prior knowledge to alkynes using the organizer.

Presentation (48 minutes)

Step 1 (10 minutes): The teacher presents a chart showing the laboratory preparation of ethyne. Ethyne contains triple bonds and is prepared in the laboratory by the action of cold water on calcium carbide. The gas evolved is passed through acidified copper II tetraoxosulphate (VI) to remove impurities such as phosphine (PH_3). The ethyne produced is collected over water and the process is accompanied by large amount of heat.

Step 2 (15 minutes): The teacher explains further by stating the physical, chemical properties and uses of ethyne. Emphasis is placed on combustion, addition and polymerization reaction. The teacher also states the test that distinguishes alkenes from alkynes.

Step 3 (13 minutes): the teacher explains by referring to the organizer on aromatic hydrocarbons that aromatic hydrocarbons resemble benzene in chemical behaviour. Benzene is obtained from the destructive distillation of coal and can also be produced from naphtha. Benzene has a molecular formula C_6H_6 . There are three alternate carbon- carbon bond in its structure. The teacher presents the structure of benzene ring to the students and explains resonance in the ring. Some derivatives of benzene include: phenol, toluene and xylene. They are derived by substituting the hydrogen atom with OH, CH_3 and dimethyl respectively.

Step 4 (10 minutes): the teacher explains the substitution and addition reactions that benzene undergoes. The uses of benzene are further explained to the students.

Recapitulation (8 minutes): The teacher does a recap of the lesson by going over the major points of the lesson. Such points include going over the laboratory preparation of alkynes; the major reaction they undergo; their uses and chemical test that differentiate between alkenes and alkynes; the structure and uses of benzene. The teacher constructs a map on aromatic hydrocarbons and unsaturated hydrocarbons with the students.

Evaluation (8 minutes): The teacher evaluates the lesson by asking questions such as;

- i. With the aid of chemical equation, describe the laboratory preparation of ethyne
- ii. State the three physical and chemical properties of ethyne
- iii. Describe a chemical test to distinguish between alkynes and alkenes
- iv. Draw the structure of benzene and state three derivatives of benzene
- v. State two uses ethyne and benzene

Summary and Conclusion (5 minutes): The teacher summarizes the lesson by correcting all misconceptions identified during evaluation. The teacher concludes the lesson by presenting assignments.

Assignments (5 minutes): The gives the students the following assignments;

Choose a member each from alkyne series and write the following:

- i. The molecular and structural formulae
- ii. The method of preparation
- iii. Its physical and chemical properties
- iv. Its uses

References:

Ababio, O. Y. (2007). New school chemistry. African Publishers, Onitsha

Ohia, G. N. C., Amasiatu, G. I., Ajagbe, J. O., Ojokuku, G. O., & Mohammed, U. (2007). Comprehensive certificate chemistry. University Press (2nd Ed.), Ibadan.

APPENDIX III
ACHIEVEMENT TEST ON HYDROCARBONS

Name:.....

Name of School:.....

Sex: Male () Female ()

Instruction: Answer all questions.

Time Allowed:1 hour

1. Hydrocarbons are classified into
(a) Alicyclic and cyclic (b) Aliphatic and aromatic (c) alkanes and alkynes (d)benzene and its derivatives
2. Methane is formed when reacts with sodiumhydroxide
(a) Sodium ethanoate (b) calcium carbide (c) tetraoxosulphate (VI)acid (d) ethoxylethane
3.is the general molecular formulae for alkynes
(a) $C_{n-2}H_{2n}$ (b) C_nH_{2n} (c) C_nH_{2n-2} (d) C_nH_{2n+2}
4. Two derivatives of benzene are
(a)phenol and toluene (b) Chloropentane and methylbenzene (c) cyclohexane and benzoic acid (d) methylbenzene and cyclobenzene
5. As the number of bonds in hydrocarbons increases, their reactivity with hydrogen
(a) increases (b) decreases (c) dissolves (d) polymerize
6. Ethyne can be reduced to alkanes by
(a) addition reaction (b) polymerization reaction (c) combustion reaction (d) decomposition reaction
7. methane is the main constituent of
(a) natural gas (b) water gas (c) coal gas (d) hydrocarbons
8. Chloropentane and dichloropentane belong to groups of compounds known as
(a) unsaturated hydrocarbons (b) alkanes (c) pentane (d) aromatic
9. In the test for ethene, the decolorization of bromine water indicates.....
(a) the presence of additives (b) that it is unsaturated (c) that it is reactive (d) that it polymerizes
10. During the laboratory preparation of ethyne, the gas evolved is passed through.....to

- (a) H_2SO_4 to become soluble (b) Acidified KMnO_4 to remove calcium (c) Acidified CuSO_4 to remove impurities (d) Ammoniacal silver nitrate to enhance coagulation
11. Ethene undergoes addition reaction with hydrogen to produce ethane. Which of the following reaction equation is correct?
- (a) $\text{C}_2\text{H}_4 + \text{H}_2 \longrightarrow \text{C}_2\text{H}_6$ (b) $\text{C}_2\text{H}_6 + \text{H}_2 \longrightarrow \text{C}_2\text{H}_8$
 (c) $\text{C}_2\text{H}_2 + \text{H}_2 \longrightarrow \text{C}_2\text{H}_4$ (d) $\text{C}_2\text{H}_2 + 2\text{H}_2 \longrightarrow \text{C}_2\text{H}_6$
12. The IUPAC name for the compound $\text{ClCH}_2\text{CH}_2\text{CH}_3$ is
 (a) chloropropane (b) propane I chloride (c) chlorobutane (d) chloropropyl
13. A hydrocarbon has a relative molecular mass of 44g. Deduce the structural formula of the compound ($\text{C}=12$, $\text{H}=1$)
 (a) CH_3CCH_5 (b) $\text{CH}_3\text{CH}_2\text{CH}_3$ (c) C_3H_8 (d) $\text{CH}_3\text{CH}_3\text{CH}_2$
14. The IUPAC nomenclature of the compound C_4H_6 is
 (a) but-2-yne (b) butyne (c) butane (d) but-1-yne
15. classification of aliphatic hydrocarbons is based on.....
 (a) molecular formula of the compound (b) the number of bonds present in their structure
 (c) the valency of carbon and hydrogen atoms (d) the natural source of hydrocarbon
16. A compound with a molecular formula C_6H_6 is.....
 (a) alkene (b) alkyne (c) benzene (d) ethane
17. A compound X is burns in oxygen to produce a smoky luminous flame. X is likely to be
 (a) carbon (b) alkane (c) alkyne (d) hydrogen
18. During the laboratory preparation of ethyne, the reaction is performed on a heap of sand due to..... that is associated with the process
 (a) the large amount of heat released (b) the smell of the gas released (c) the ethene produced is volatile (d) the presence of calcium carbide in the reaction mixture
19. The liquid hydrocarbon likely to be found in fraction of crude oil used for domestic cooking is
 (a) C_3H_8 (b) C_5H_{12} (c) $\text{C}_{13}\text{H}_{28}$ (d) $\text{C}_{20}\text{H}_{42}$
20. A colorless hydrocarbon with a sweet smell undergoes substitution reaction. The hydrocarbon is likely to be
 (a) alkanol (b) benzene (c) ester (d) methane
21. Which type of reaction is illustrated by the following equations



- (a) Addition (b) cracking (c) hydrogenation (d) polymerisation
22. Ethene molecule can be added to one another to form a long chain compound called a
(a) dimer (b) monomer (c) polymer (d) trimer
23. which of the following raw material is used in plastic industry
(a) ethene (b) methane (c) calcium (d) hydrogen
24. which of the following reaction is common to all hydrocarbons?
(a) combustion (b) addition (c) polymerization (d) condensation
25. How many isomers does $\text{C}_3\text{H}_6\text{Cl}_2$ has?
(a) 2 (b) 3 (c) 4 (d) 5
26. which of the following organic compounds would decolorize bromine water?
(a) Benzene (b) cyclobutane (c) hexane (d) pentane
27. when bromine is added to ethene at room temperature, the compound formed is
.....
(a) 1,1,-dibromoethane (b) 1,1,-dibromoethene (c) 1,2,-dibromoethane (d) 1,2,-
dibromoethene
28. Hydrocarbon molecules with the same molecular formula and different structural formula are called
(a) isomers (b) monomers (c) polymers (d) isotopes
29. In determining the IUPAC nomenclature of an hydrocarbon, the first step is to identify the
(a) total number of hydrogen atoms in the compound
(b) total number of hydrogen atoms in the compound
(c) longest continuous carbon-carbon chain in the compound
(d) substituent groups of the compound
30. The structural formula for alkanes differ from other hydrocarbons because alkanes have
(a) carbon-carbon double bond in their structure
(b) carbon-carbon single bond in their structure
(c) carbon-carbon double and single bonds in their structure
(d) carbon-carbon triple bond in their structure
31. The following are true of the structural formula in hydrocarbons EXCEPT that it provides

- (a) information on the location of the bonds
 (b) details of locations of the atoms in the molecules of the compound
 (c) information on the bond type
 (d) it provides information on the bond angle
32. The properties of hydrocarbons include the following EXCEPT
 (a) low density (b) poor conductors of electricity (c) low melting points (d) very soluble in water
33. Natural gas consists mostly of hydrocarbon, which of the following hydrocarbons is present in a natural gas
 (a) propane (b) butane (c) octane (d) methane
34. Heptane is an hydrocarbon that contain..... carbon atoms
 (a) 7 (b) 6 (c) 9 (d) 5
35. Which of the following statements is not true about alkanes
 (a) they are non-polar molecules (b) they are soluble in water (c) they have low boiling point (d) they are insoluble in water
36. The nomenclature of the compound with the structural formula is
- $$\begin{array}{c}
 \text{H} \\
 | \\
 \text{H} - \text{C} - \text{C} \equiv \text{C} - \text{H} \\
 | \\
 \text{H}
 \end{array}$$
- (a) Propyne (b) Propene (c) propane (d) pentane
37. Chlorination reaction among alkanes is an example of
 (a) substitution reaction (b) combustion reaction (c) redox reaction (d) none of the above
38. Hydrocarbons with multiple bonds are referred to as..... hydrocarbons
 (a) saturated (b) unsaturated (c) semisaturated (d) supersaturated
39. When the number of carbon atoms in an hydrocarbon molecule increases, the number of possible isomers.....
 (a) decrease (b) increases (c) none of the above (d) all of the above
40. A saturated hydrocarbons is also an
 (a) alkane (b) alkenes (c) alkynes (d) alkynes
41. Which of the following is true about alkenes

- (a) an hydrocarbon with at least one double bond between 2 carbons atoms
 - (b) an hydrocarbon with at least one triple bond between 2 carbons atoms
 - (c) an hydrocarbon with single bond between all carbons atoms
 - (d) all of the above
42. Cyclohexane is an example of cyclic hydrocarbons that contains
- (a) triple bonds (b) single bonds (c) double bonds (d) resonance
43. A ring structured hydrocarbon that has a sweet smell and possess double bond is.....
- (a) benzene (b) hexane (c) hexane (d) cyclohexane
44. Organic compounds that has benzene- like rings are called
- (a) aromatic compounds (b) circle compounds (c) aldehydes (d) ketones
45. Hydrogenation reaction is possible for compounds that possess
- (a) single and double bonds (b) double and triple bonds (c) single and triple bonds (d) none of the above
46. The ability of carbon to form bonds with other carbon atoms resulting to a chain is called
- (a) catenation (b) elimination (c) addition (d) distillation
47. A reaction of calcium carbide with water gives a major hydrocarbon called
- (a) methane (b) ethane (c) propane (d) ethyne
48. The simplest member of organic compound is.....
- (a) methane (b) ethane (c) propane (d) carbon
49. Hydrocarbons are compounds that contains.....
- (a) carbon and oxygen (b) oxygen and hydrogen (c) hydrogen and carbon (d) carbon and oxygen
50. which of the following homologous series does not belong to the aliphatic group.
- (a) aromatic (b) alkanes (c) alkynes (d) alkenes

APPENDIX IV

MARKING GUIDE

1. B	26. A
2. A	27. C
3. C	28. A
4. A	29. C
5. A	30. B
6. A	31. D
7. A	32. D
8. B	33. D
9. B	34. A
10. C	35. B
11. A	36. A
12. A	37. A
13. B	38. B
14. A	39. B
15. B	40. A
16. C	41. A
17. C	42. B
18. A	43. A
19. C	44. A
20. B	45. B
21. B	46. A
22. C	47. D
23. A	48. A
24. A	49. C
25. C	50. A

APPENDIX V

TABLE OF SPECIFICATION

Contents	Remember	Understand	Apply	Analyze	Evaluate	Create	Total
Hydrocarbons	1, 16, 38, 40, 46, 49, 50	5, 15, 21, 24, 32, 33, 39, 45	13, 19	-	-	-	17
Nomenclature	29	12, 36	-	14	-	-	4
Isomerism	28	25			31	-	3
Aromatic Hydrocarbons	4, 26, 43, 44	-	-	-	20	-	5
Methane	7, 8, 34, 48	2, 35, 37, 42,			30	-	9
Ethene		9, 11, 22,	23	27	41	-	6
Ethyne	3, 47	6	17	10	18	-	6
Total	19	19	4	3	5	-	50

APPENDIX VI

QUESTIONNAIRE ON STUDENTS' PERCEPTION ON THE USE OF CONCEPT MAP GRAPHIC ORGANIZER

Dear Respondents,

This questionnaire is designed to elicit responses on your perception of the use of concept map graphic organizer in learning hydrocarbons. You are assured that information provided will be treated with utmost confidentiality and for the purpose of this study only. Hence, you are required to be honest in your responses.

Thank you.

SECTION A

Name:.....

Name of School:.....

Sex:.....

SECTION B

Please read each of the following statements and thick the response that best describe your perception about the use of graphic organizer in learning hydrocarbons.

Items	Perceived usefulness of Concept Map Graphic Organizer	SA	A	D	SD
1	I like the use of concept map graphic organizers				
2	I enjoyed drawing mind map for studying hydrocarbons				
3	Using a concept map graphic organizer for hydrocarbons helped me organize information				
4	The use of concept map graphic organizers helped me understand the structures of the various classes of hydrocarbons				
5	Using concept map graphic organizers helped me understand the uses of the various classes of hydrocarbons				
6	I found the use of concept map graphic organizer to be a difficult procedure to follow				
7	A different strategy should have been used for me to understand the chemistry of hydrocarbon				
8	I was given adequate time to examine the concept map graphic organizer				

9	I put a lot of effort into studying my concept map graphic organizer so as to understand related concepts in hydrocarbons.				
	Perception towards the use of Concept Map Graphic Organizer (GO) in learning hydrocarbons				
1	I would willingly consider the use of concept map graphic organizer in learning other topics in chemistry because it is easy to use				
2	The use of concept map graphic organizer in the teaching process helped me to maintain my concentration during learning				
3.	Learning hydrocarbon with concept map graphic organizer has made the topic one my favorite topics in chemistry				
4	I prefer the constant use of concept map graphic organizer by my teacher than other strategies				
5	The use of linking words in the maps facilitates my better understanding of the concepts				
6	When I used concept map graphic organizer, I found the concepts more meaningful and understandable				
7	The use of concept map graphic organizer make learning experiences easier because it helps me to connect the relationships between concepts				
8	My work is better organized whenever I use concept map graphic organizer, hence I prefer using it to other strategies				
9	I prefer being given any homework using concept map graphic organizer because it gives me direction on what I need to learn.				

Adapted from Goodnough and Woods (2002)

APPENDIX VII

QUESTIONNAIRE ON STUDENTS' PERCEPTION ON THE USE OF MIND MAP GRAPHIC ORGANIZER

Dear Respondents,

This questionnaire is designed to elicit responses on your perception of the use of concept map graphic organizer in learning hydrocarbons. You are assured that information provided will be treated with utmost confidentiality and for the purpose of this study only. Hence, you are required to be honest in your responses.

Thank you.

SECTION A

Name:.....

Name of School:.....

Sex:.....

SECTION B

Please read each of the following statements and thick the response that best describe your perception about the use of graphic organizer in learning hydrocarbons.

Items	Perceived usefulness of Mind map Graphic Organizer	SA	A	D	SD
1	I like the use of mind map graphic organizers				
2	I enjoyed drawing mind map for studying hydrocarbons				
3	Using a mind map graphic organizer for hydrocarbons helped me organize information				
4	The use of mind map graphic organizers helped me understand the structures of the various classes of hydrocarbons				
5	Using mind map graphic organizers helped me understand the uses of the various classes of hydrocarbons				
6	I found the use of mind map graphic organizer to be a difficult procedure to follow				
7	A different strategy should have been used for me to understand the chemistry of hydrocarbon				
8	I was given adequate time to examine the mind map graphic organizer				

9	I put a lot of effort into studying my mind map graphic organizer so as to understand related concepts in hydrocarbons.				
	Perception towards the use of Mind map Graphic Organizer (GO) in learning hydrocarbons				
1	I would willingly consider the use of mind map graphic organizer in learning other topics in chemistry because it is easy to use				
2	The use of mind map graphic organizer in the teaching process helped me to maintain my concentration during learning				
3.	Learning hydrocarbon with mind map graphic organizer has made the topic one my favorite topics in chemistry				
4	I prefer the constant use of mind map graphic organizer by my teacher than other strategies				
5	The use of linking words in the maps facilitates my better understanding of the concepts				
6	When I used mind map graphic organizer, I found the concepts more meaningful and understandable				
7	The use of mind map graphic organizer makes learning experiences easier because it helps me to connect the relationships between concepts				
8	My work is better organized whenever I use mind map graphic organizer, hence I prefer using it to other strategies				
9	I prefer being given any homework using mind map graphic organizer because it gives me direction on what I need to learn.				

Adapted from Goodnough and Woods (2002)

APPENDIX VIII

FOCUS GROUP INTERVIEW PROTOCOL

Date:

Group interviewed:

Interview completed by:

Brief script prior to interview:

Good day everyone. I am I hereby welcome every participant to this session of interview. It is my wish to get to know individuals by a brief introduction. I will like the first person to kindly introduce him/herself while others follow. The intent of this small group is to conduct an interview called a focus group and you have been selected to be part of the group.

This focus group will help us to understand how graphic organizer influences your performance in organic chemistry. My purpose of meeting you today is to learn your thoughts, feelings and experience on the use of graphic organizer to learn organic chemistry. Your insights will assist educators to make improvements in the teaching and learning of organic chemistry.

I would like to thank you for your willingness to participate in the interview aspect of this study and assure you that your response remains confidential. This interview will last for 60 minutes during which I will be asking you about how graphic organizer has influenced your understanding of organic chemistry. Kindly note that reports will be written in a manner that no individual comment is attributed to a particular person, and there is no right or wrong answers. Hence, feel free to share your own point of view even if it differs from what others have said.

Before, we begin this interview, you can feel free to ask questions and I will be glad to respond.

- To begin this interview, do you consider chemistry as an interesting science subject or a difficult one?
- I would like you to talk briefly about your experience in the recent organic chemistry class

- Based on your experience in the just concluded class would you infer that you understood the areas that were covered by the teacher and which area do you consider difficult to understand.

Probe: Probe into specific areas of difficulties

Follow-up: what do you think is/are responsible for the difficulties?

Probe: Teachers' method of teaching

Classroom organization

Interest in organic chemistry

- Do you think the organizer you studied had influenced your understanding of organic chemistry?

If yes, how did the organizer help you improve your performance?

If no, does that mean that the organizer you studied did not have any influence your understanding of organic chemistry?

Brief script: definitely, you will have a mindset on the use of graphic organizer based on your classroom experience in utilizing it to learn organic chemistry and I expect that you will have some observations about it.

- As a result of your experience on the use of the organizer in the organic chemistry class. How would you describe the effectiveness of the organizer?

Probe: Did you benefit from it?

Follow-up:

If yes, In what way did the organizers help you to understand the chemistry of hydrocarbons?

If no, what do you think is responsible for this? How would you compare your understanding of chemistry topics taught without organizers and this?

Your response in the questionnaire indicates a (positive/negative) perception on the use of graphic organizers

- Having used graphic organizer to study the chemistry of hydrocarbons, would you recommend its use for teaching other topics in chemistry?

If yes, does that mean that the graphic organizer is a good tool that should be used for teaching and learning?

If no, what would you have preferred?

Follow-up:

Are you willing to adopt it as a learning tool? Provide justification for your response.

- Before we conclude this interview, is there something you would like to share with me about your experience when using the organizer that you think influenced your performance that we have not discussed.

Thank you for your time

APPENDIX IX

EMERGING CODES AND THEMES FROM FOCUS GROUP INTERVIEW (CONCEPT MAP)

Themes	Sub Themes	Codes
Support for cognitive development	Facilitates learning	*Confirmation of significant role of the maps in learning nomenclature *affirmation of the relevance of the map towards understanding organic chemistry. *Acknowledgment of positive role of the map for revision *recognition of relevance of the map *certainty of positive influence of the map *acknowledgement of mastery of contents of the map *certainty of non-ambiguous nature of map *acknowledgement of relevance of the map as summary tool *preference for map as an independent learning tool
	Identification of relationships among concepts	*identification of linking phrase *recognition of relationship among concepts *identification of classes on the map *identification of arrows with linking words *recognition of the role of linking phrases
	Processing information on the maps	*Acknowledgement of simplicity of the map in presenting information. *acknowledgement of getting details from the map within a short time *Identification of salient point with less stress. *acknowledgement of explicit nature of the map *acknowledgement of details in the map *recognition of details on the map *certainty of clarity of the concepts in the map
	Reference to prior knowledge	*Ascertained rote learning *identification of prior knowledge on the map *recognition of role of prior knowledge
Areas of difficulty	Identification of difficult areas	*acknowledgement that reactions of hydrocarbons were not understood *ascertained difficulty in polymerization *confirmation that concepts of homologous series were not understood *acknowledgement of areas of difficulty in aromatic *certainty that isomerism is not clear *Acknowledgement of positive feelings towards the map.

Implications for affective domain of learning	Development of interest towards chemistry	*confirmation of interest towards the map. *acknowledgement of interest in learning with the maps *affirmation that maps arouse learners interest
Support for use maps	Preference for use maps	*support for repeated use of maps for teaching hydrocarbons *acknowledge support for continuous use as supplementary resources * certainty of using the map as learning tool *preference for using maps as advance organizer *improvement of concentration in class
Shortcomings for use of maps	Discourage using maps for learning	*displeasure towards frequent use of the map *maps negatively influence learning *learning would be progressive without the maps *discouraged maps for introducing new topics *discouragement of sole use of the map
	Barriers to learning with the map	*maps requires more clarification *certainty about peer influence in understanding the maps *unfamiliar terminologies were barriers to understanding the topic *personal characteristics hindered understanding *Identification of skipped gradient
	Decline for subsequent use of maps	*decline support for maps as advance organizer

EMERGING CODES AND THEMES FROM FOCUS GROUP INTERVIEW (MIND MAP)

Themes	Sub Themes	Codes
Support for cognitive development	Facilitates learning	*recognition of maps aiding grasp of information with less effort *acknowledgement of maps facilitating learning *recognition of positive role of map as advance organizer *acknowledgement of maps for improved understanding *acknowledgement of maps facilitating learning with less effort *certainty that map was helpful *affirmation of relevance of maps prior to instruction *acknowledgement of positive influence of the map *recognition of positive role of the map in avoiding misconceptions * acknowledgement of concentration during lesson
	Identification of relationships among concepts	*recognition of relationships among concepts in the map *affirmation of understanding of relationships among concepts in the map *identification of differences among concepts in the map
	Processing information on the maps	*acknowledgement of understanding information on the maps *recognition of details on the map *ease of identification of salient points *recognizes simplicity of the maps in showing relationship *acknowledgement of concise nature of the map
Areas of difficulty	Identification of difficult areas	*certainly, aspects of isomerism were not understood *experienced difficulty in geometric isomerism *acknowledgement of decline understanding as lesson progresses
Implications for affective domain of learning	Development of interest towards chemistry	*acknowledgement of motivation to learn through the maps *acknowledgement of interest towards using the map *maps arouse curiosity *acknowledgement of positive feelings towards learning with the map
Support for use maps	Preference for use maps	*certain about recommending it for subsequent use *convinced about subsequent use of map for easier understanding *convinced about subsequent use of map for quick reference *certainty of using map as learning tool

Shortcomings for use of maps		*ascertained that maps should be used as advanced organizer
	Discourage using maps for learning	*ascertaining that not all topics should be taught with the maps *acknowledgement of deterred attention as a result of using map as advance organizer
	Barriers to learning with the map	*insufficient time to understand teachers' explanation using the map
	Decline for subsequent use of maps	*discouraged about using the map as an advance organizer

APPENDIX X

BUDGET

Description of Items	Expected from	Total
	Sponsor	
1.0 Personal Cost/ Allowances		
1.1 Research Assistance (3)	Student	10,000
1.2 Research Information	Student	10,000
Sub-total (not> 20% of Budget)		20,000
2.0 Equipment		
2.1 HP Laptop	Student	115,000
2.2 HP Printer	Student	65,000
2.3 Modem	Student	4,500
2.4 Flash Drive	Student	4,000
Sub-total		188,500
3.0 Supplies and Consumables		
3.1 Textbooks	Student	75,500
3.2 Printing Papers	Student	60,000
3.3 Monthly Subscription for Data Bundles @ 2,500 per month	Student	75,000
Sub-total		190,500
4.0 Data Collection Analysis		
4.1 Test Administration	Student	15,000
4.2 Analysis	Student	45,000
Sub-total		60,000
5.0 Travels		
5.1 Researcher	Student	6,000
Sub-total		6,000
6.0 Dissemination		
6.1 Conferences	Student	30,000
6.2 Journal Publication	Student	30,000
6.3 Workshops	Student	45,000
Sub-total		105,000
7.0 Miscellaneous		
7.1 Miscellaneous	Student	100,000
Sub-total		100,000
Grand Total		690,000

APPENDIX XI

TIME LINE

	01/12/16	01/01/17	01/02/17	01/02/17	01/03/17	01/04/17	01/05/17	01/06/17	01/07/17	01/08/17	01/09/17	01/10/17	01/11/17	01/12/17	01/01/18	01/02/18	01/03/18	01/04/18	01/05/18	01/06/18	01/07/18	01/08/18	01/09/18	01/10/18	01/11/18	01/12/18	01/01/19	01/02/19	01/03/19	01/04/19	01/05/19	01/06/19	01/07/19	01/08/19	01/09/19	01/10/19	01/11/19	01/12/19	01/01/20	01/02/20
MONTH	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	20	1	2	3	4	5	6	7	8	9	30	1	2	3	4	5	6	7	8	9	40
TASK																																								
Survey of Literature																																								
Write Proposal (Programmes Without Coursework)																																								
Write Proposal (Programmes With Coursework)																																								
Gather Data (Programmes with Coursework)																																								
Thesis Writing																																								
Write Introduction																																								
Revise Introduction																																								
Write Methodology																																								
Revise Methodology																																								
Approval for proposal Seminar																																								
Awaiting schedule for proposal seminar																																								
Proposal presentation																																								
Effecting proposal corrections for protocol																																								
Protocol presentation																																								
Correction of Protocols																																								
Analyses, Results and Discussion																																								
Write Conclusions																																								
Revise conclusions																																								
Acknowledgements, Appendices, etc.																																								

APPENDIX XII

Group Embedded Figure Test

Name:

Class: Gender: *Male*() *Female* ()

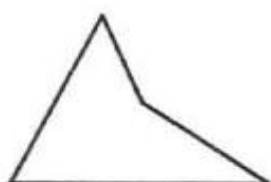
Date:

Instruction: This is a test of your ability to find a simple form where it is hidden within a complex pattern.

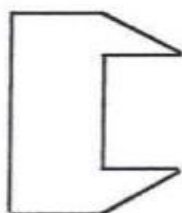
The results of this test will not affect your subject assessment in any way

Time allowed: 20 minutes

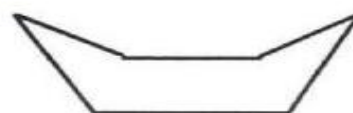
Study the shapes below and locate them in the embedded figure



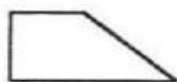
A



B



C



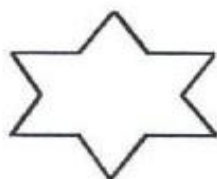
D



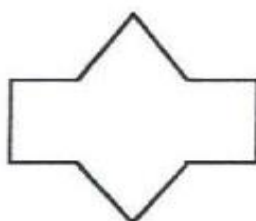
E



F

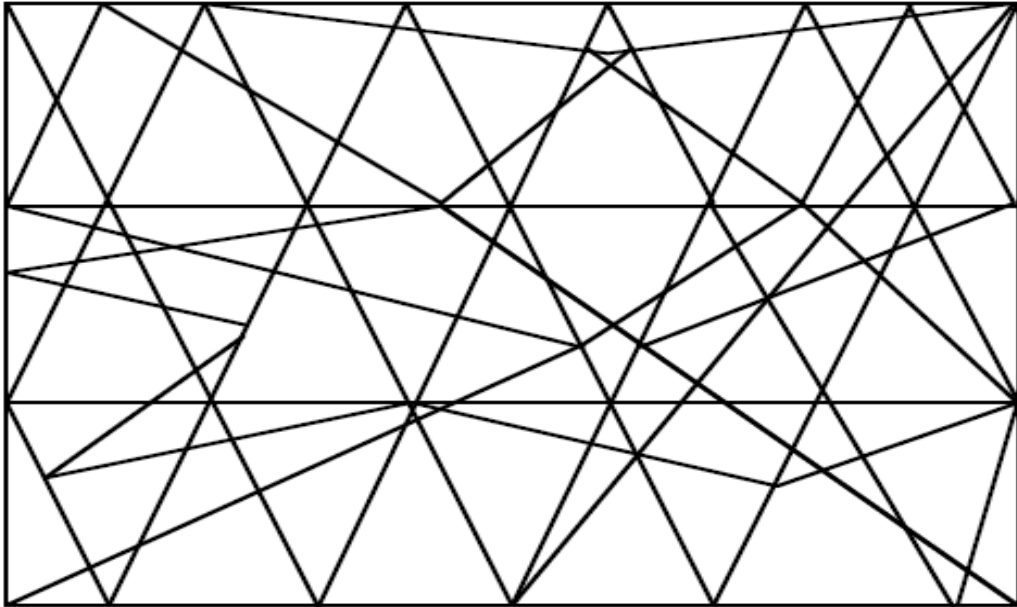


G

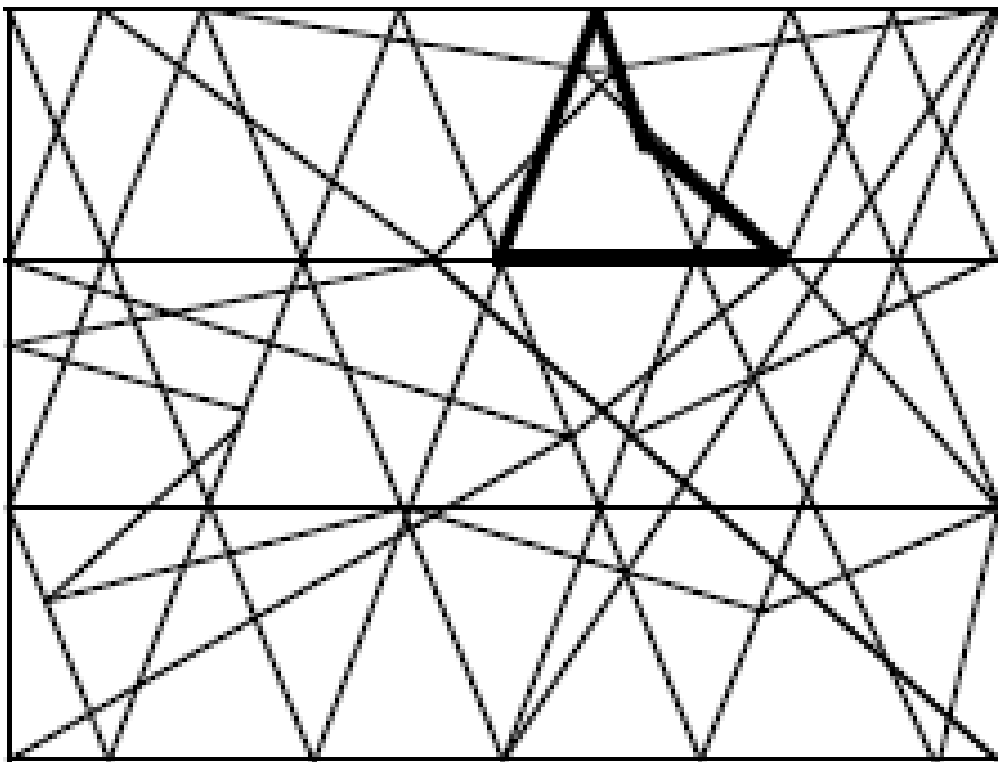


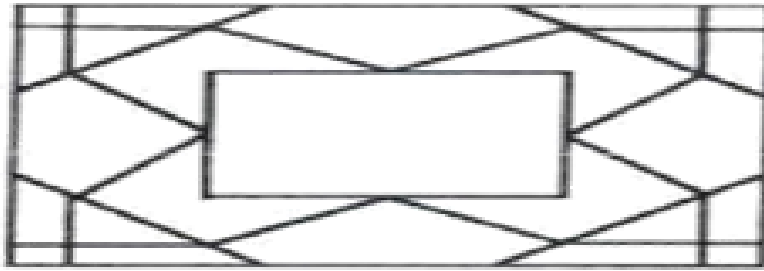
H

Example

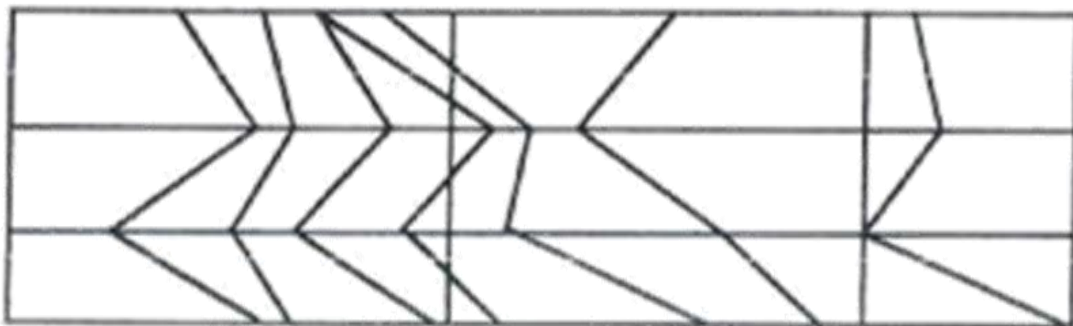


Find shape A

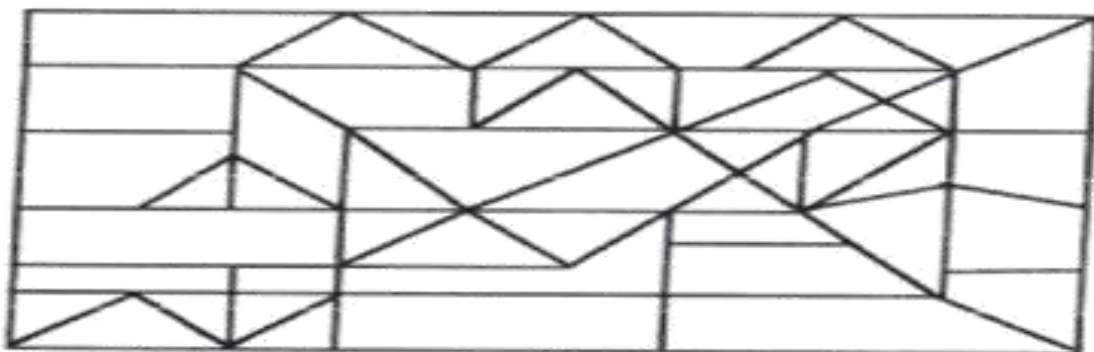




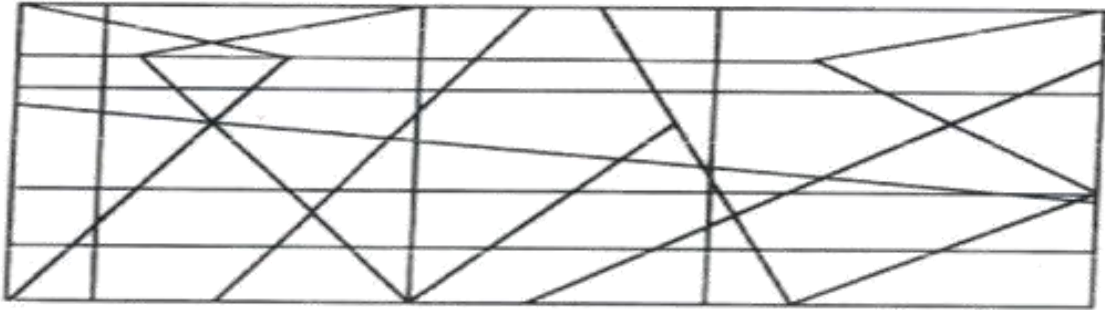
Find shape B



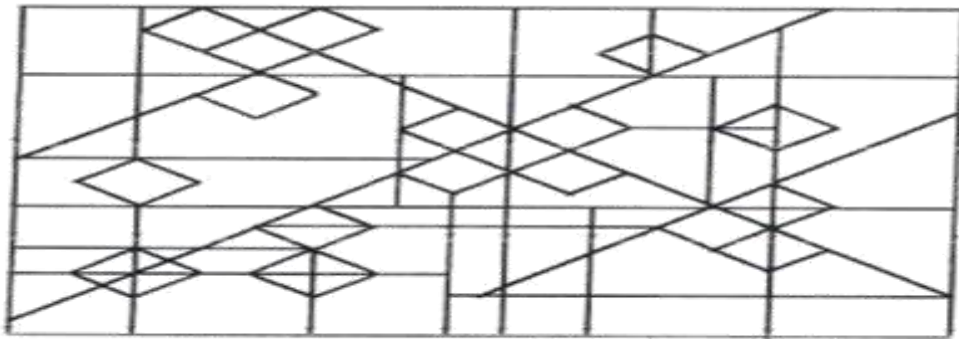
Find shape D



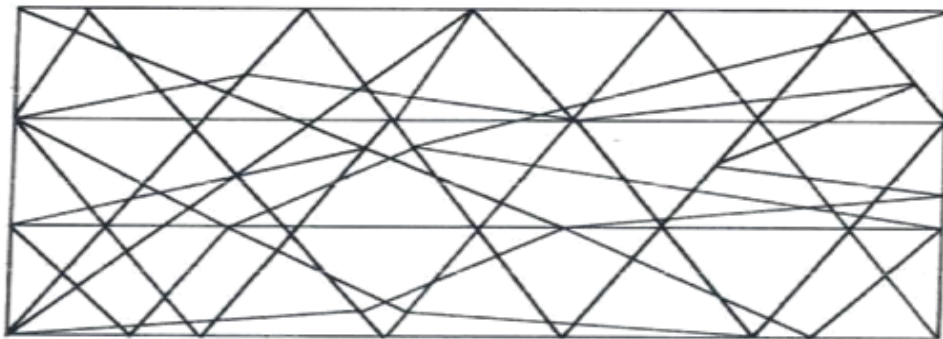
Find shape H



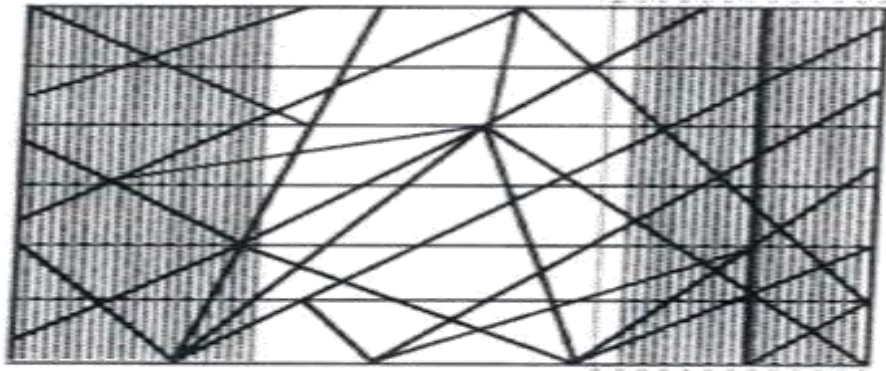
Find shape E



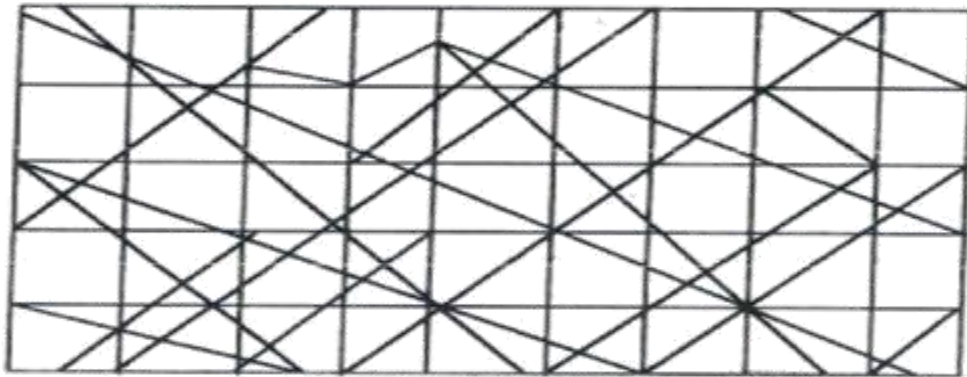
Find shape F



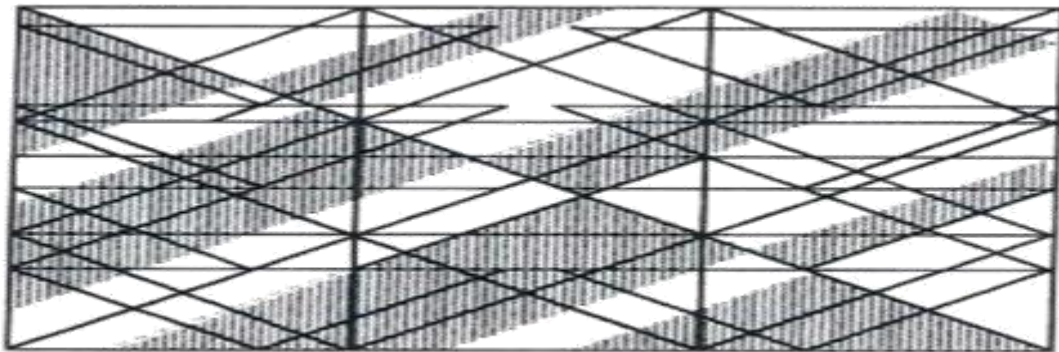
Find shape A



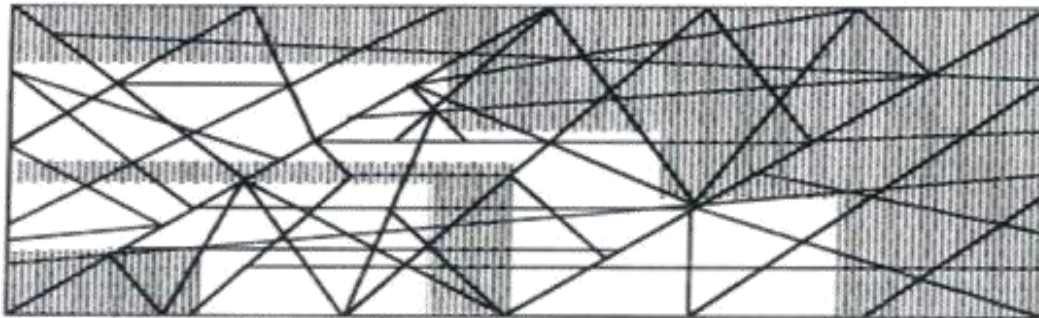
Find shape E



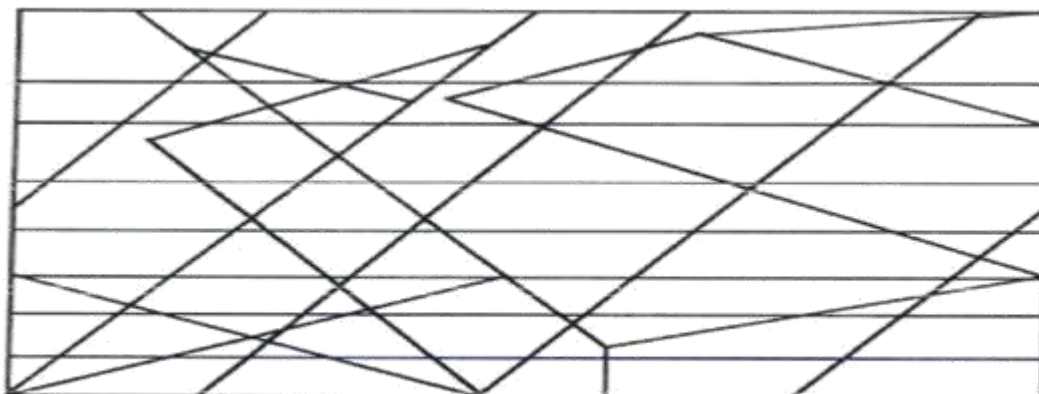
Find shape H



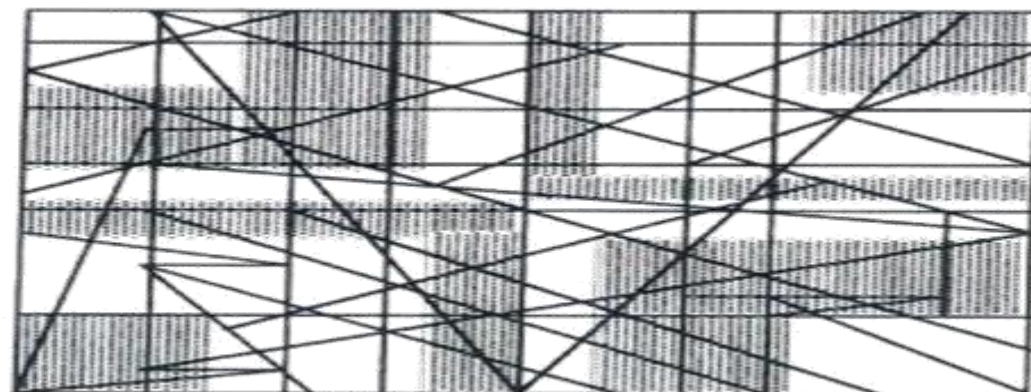
Find shape D



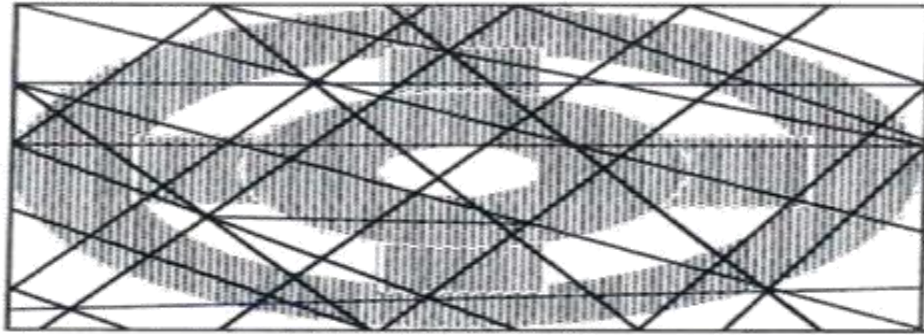
Find shape G



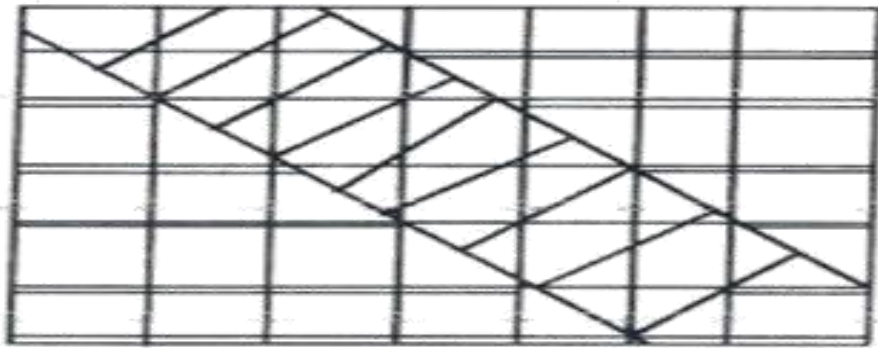
Find shape C



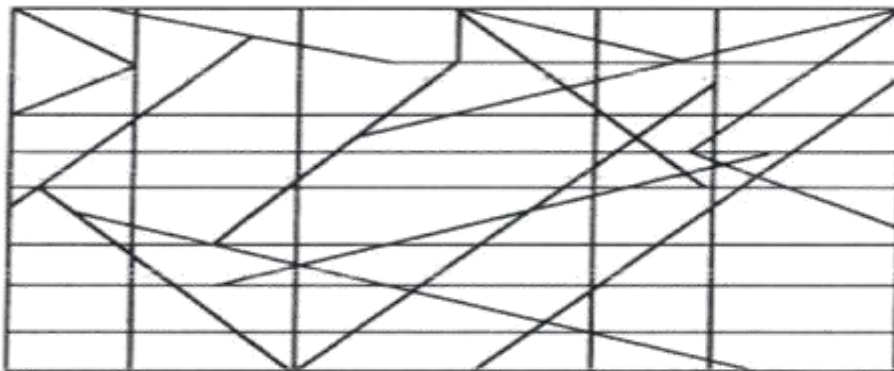
Find shape B



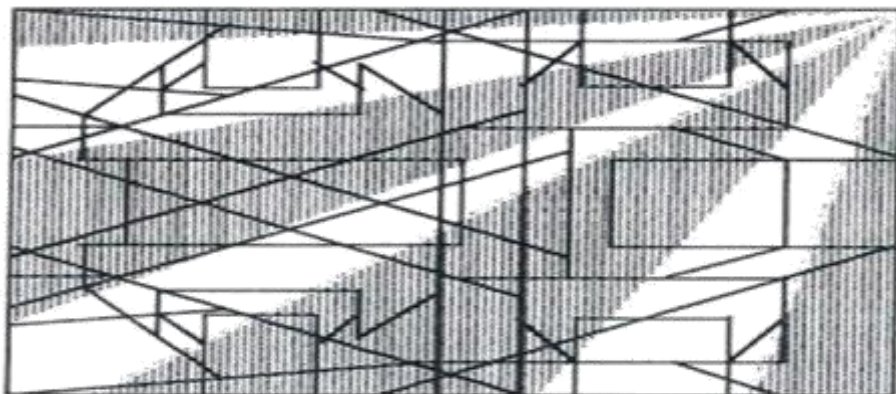
Find shape G



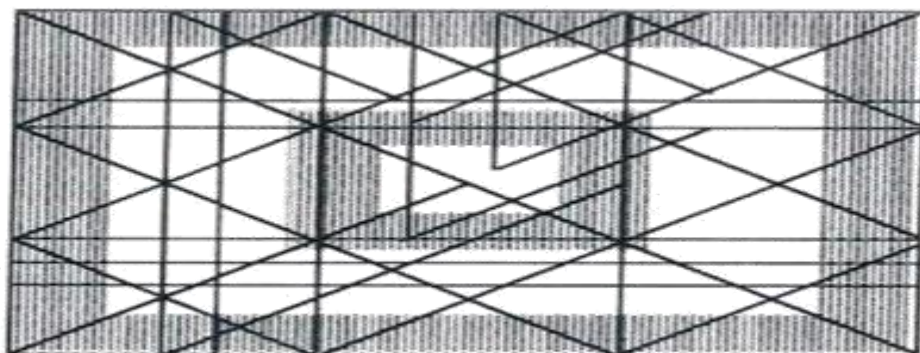
Find shape H



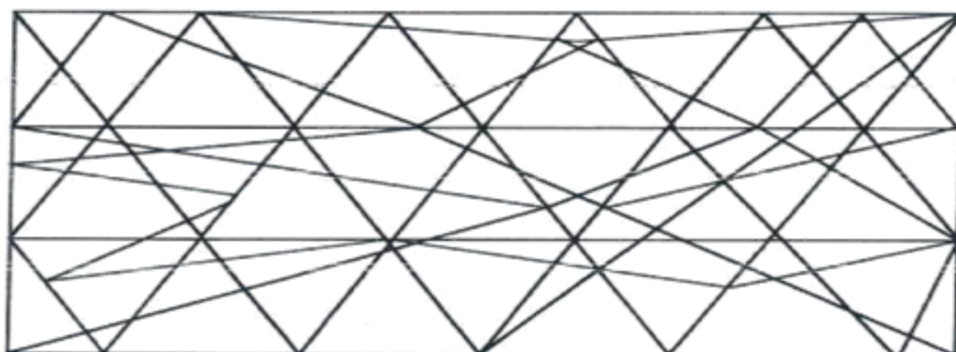
Find shape C



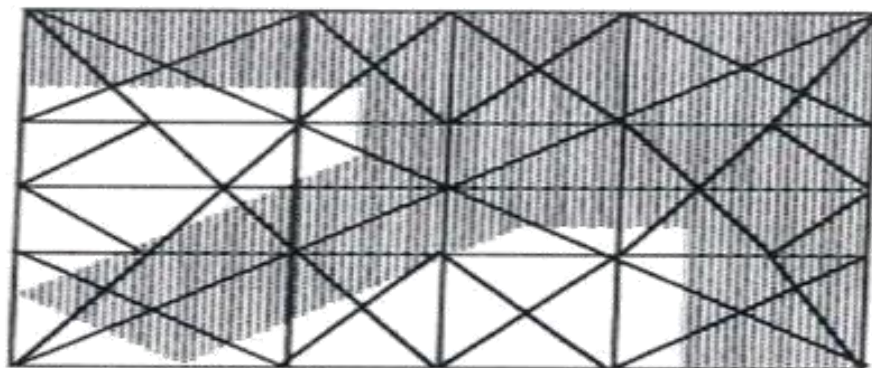
Find shape B



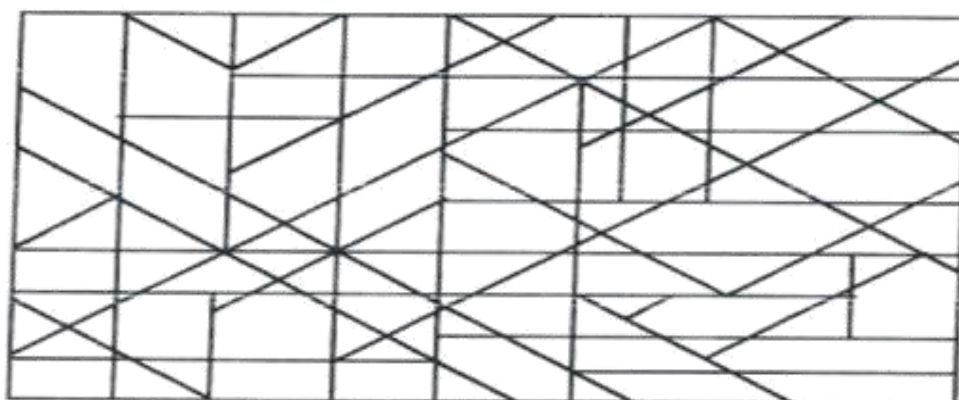
Find shape D



Find shape A



Find shape E



Find shape F