

CHAPTER ONE

INTRODUCTION

Background to the Problem

Science is an indispensable tool for the economic, social, political and technological development of every nation. The significant role of science in modern day world cannot be over-emphasized, thus the interaction of man with science is certainly imperative. Nations of the world are categorized as developed or developing based on the extent of their scientific and technological development. Science has potential for the technological advancement of the nations and it has been defined by various scholars. For instance, Aniodoh and Egbo (2013) described science “as a way of thinking in pursuit of understanding nature, a way of investigating and a body of established knowledge” (p.268).

Science plays a very significant role in the development of any nation; the development depends largely on the scientific and technological literacy possessed by the citizens (Omiko, 2017; Nnoli, 2015). Rull (2014) pointed out areas that science has contributed immensely to human life in the areas of medicine, shelter, leisure, communication, security, education, transportation and sports. Development and practical changes of a nation depend on these inventions and innovations of science and technology, this accounts for why most developing countries attach importance and more emphasis on science learning (Ogbonna, 2014).

It has been observed that science and technology have become an integral part of the world’s culture and any nation that neglects science and technology does it to its own disadvantage. This is because a solid foundation in the sciences is crucial for any nation to attain its scientific and technological developmental height (Okeke, 2011). The roles of scientific principles, facts, values and norms learnt by the students through science

subjects like Chemistry, Physics, Biology, and Agriculture, among others, cannot be overemphasized. Acquisition of scientific skills depends solely on the choice of teaching strategy by the teacher.

Science teachers can help students acquire scientific skills by making teaching and learning activity based and learner-centered. Activity based and learner-centered instructional strategy provides opportunity for students to develop and use social and inquiry skills which make them to participate as responsible members of a team, engage in formulating and testing scientific concepts and hypotheses (Chinweoke, 2016). Skills development is synonymous to inquiry approach, which is learning by doing, for it is only by practice that skills in doing things develop in individuals (Igboanugo, 2015). Holbrook (2011) observed that science teachers have used quite a number of teaching methods and strategies such as discovery, expository, question, discussion, demonstration, guided inquiry among others and these methods seem not have yielded expected result.

According to Novak and Gowin (1984), learning is personal and idiosyncratic as learner has to construct his or her own knowledge. Therefore, for meaningful learning to take place, it requires determination, interest, commitment and active participation on the part of the learners. In other word, learning could be meaningful when learners develop interest in the subject matter and construct new knowledge based on their understanding and assimilation of the concept.

In line with the Federal Government of Nigeria's assertion on strategies for effective teaching and learning of science in its national policy on education, science teachers need to adopt innovative teaching approaches which had been proved effective in enhancing learning outcomes. The inability of teachers to adopt innovative teaching strategies in teaching and learning science subjects particularly chemistry, because of its

abstract nature, has resulted into persistent poor performance (Ikeobi, 2010; Omiko, 2017). Odutuyi (2015) described chemistry as the central science because it serves as interface to practically all the other sciences as well as many other areas of human endeavor. Chemistry has also been defined as the scientific study of the structure of substances, how they react when combined or in contact with one another and how they behave under different conditions (Hornby, 2015).

The worth of chemistry as an indispensable science subject in the Senior Secondary Schools (SSS) curriculum cannot be underestimated. This is stated in the objectives of chemistry curriculum by the Federal Ministry of Education that, chemistry curriculum aims at facilitating smooth transition in the use of scientific concepts and techniques acquired in chemistry from secondary to higher institutions of learning. It also enables the students to have fundamental facts in chemical concepts and assumptions, by effective choice and arrangement of content. Furthermore, it demonstrates chemistry and its links with industry, everyday life, hazards and benefits. It equally shows the relationship of Chemistry with other subjects as well as providing a complete course for students who are unable to proceed to higher education. In addition, it provides solid foundation for a post-secondary course (FME, 2009).

Chemistry has contributed greatly towards provision of basic needs and improving quality of human life (Okewande, 2018). As a result of this, the importance and uses of chemistry to everyday life are obvious. For instance, the knowledge of chemistry has been useful in the production of insecticides, herbicides, pesticides, fertilizer for improving agricultural production and storage. Chemistry plays a key role in the development of drug through which many diseases have been cured or alleviated to prolong human's life span. The knowledge of chemistry has helped in formulation of

color used in dyeing clothes, as well as purification of water and reuse of waste products (Abdulhamid & Abdulahi, 2018).

Despite the awareness of the importance of science to socio-economic and technological development of any nation, students' achievement in biology, physics and chemistry as pure science subjects which are taught in Nigerian senior schools has been inconsistent. For instance, available data in Table 1 authenticate the inconsistency in students' achievement in the sciences especially in chemistry.

Table1

Candidates' Enrolment and Performance in May/June Senior Secondary Certificate Examination in Biology, Chemistry and Physics in Nigeria 2012- 2016

Year	Biology			Chemistry			Physics		
	Total sat	Credit pass	%	Total sat	Credit pass	%	Total sat	Credit pass	%
2012	1,646,150	587,040	35.66	627,302	270,570	43.13	624,658	429,415	68.74
2013	1,648,363	852,717	51.73	639,296	462,517	72.34	637,023	297,988	46.77
2014	365,384	766,971	56.17	636,268	397,649	62.49	635,729	386,270	60.76
2015	1,390,234	798,246	57.42	680,357	412,323	60.60	684,124	410,543	60.01
2016	1,200,367	740,345	61.68	706,873	408,122	57.74	705,125	415,655	58.95
2017	580,449	394,898	68.03	377,970	320,635	84.83	377,851	205,757	54.45
2018	1,087,063	679,299	62.48	728,551	424,231	58.22	728,354	571,687	78.49
2019	1,033,304	775,103	75.01	726,132	566,156	77.96	725,853	565,746	77.94

Source: West African Examinations Council (WAEC), 2019. National Head Office, Yaba , Lagos.

Specifically, the result of WASSCE (2012) revealed that the percentage of students who passed chemistry at credit level was 43.13%. This percentage is below average which indicates students' poor performance in the subject. Nevertheless, there was an improvement in 2013 with an excellent performance of 72.34% of students who

sat for chemistry passed at credit level. One would expect this record of giant success to be sustained in the subsequent years to even hit a record of 90% and above. However, it could be observed that there was a fluctuating performance of students, the percentage decreased to 62.49% in 2014, 60.60% in 2015 and deteriorated to 57.74% in 2016. In 2017, there was a remarkable improvement in students' performance when 84.83% of students who sat for chemistry passed at credit level but decreased to 58% in 2018. The percentage rose again to 77.96 % in 2019 (WAEC, 2019)

Similarly, the National Examinations Council (NECO) senior school certificate results for 2010 revealed that 43 percent of the candidates that sat for the examination passed at credit level in biology, 29.49 percent in physics and 36.18 percent in chemistry (Amuche, Amuche, Bello & Marwan, 2014). On the same note, the Registrar and Chief Executive Officer of NECO reported that mass failure with high degrees of malpractices was recorded in core subjects like biology, chemistry, physics and further mathematics in 2011 June/July Senior School Certificate Examination (SSCE) results ("NECO releases results", 2011) The question is then, why this inconsistency in the performance of students in Senior School Certificate Examinations especially in Chemistry?

In search of answers to the questions of "why the inconsistency of the students' performance in chemistry"? and How can the occurrences of rise and fall in the performance of students in chemistry be curbed and the improvement is sustained in subsequent years? Many factors such as poor teaching methods and strategies, students' negative attitude and lack of interest in the subject, poor mathematical background, poor study habit, lack of laboratory activities, among others, have been reasons adduced for the inconsistent performance of students in chemistry (Alam, Oloruntegbe & Orimogunje, 2010; Bamiro, 2015; Igboanugo & Njoku, 2015; Lamidi, Oyelekan & Olorundare, 2015; Ogbonna, 2014; Ogbu, 2012).

The WAEC Chief Examiner's Reports on students' strengths and weaknesses of May/June 2010 and 2011 indicated that candidates had weakness in answering questions on rates of chemical reactions. Therefore, it is important to investigate strategies that will be effective in teaching and learning abstract concepts such as rates of chemical reactions.

The rates of chemical reactions as a topic in chemistry has been established as an abstract concept which has made learning of the topic difficult. Comprehension of concept of rate of chemical reactions is also a prerequisite in understanding other chemical concepts such as chemical equilibrium and stoichiometry (Kaya & Geban, 2011). Samba and Eriba (2012) submitted that chemistry has been described as difficult subject by many students because of its abstract in nature. Eze and Onyenwe (2018) and WAEC Chief Examiners' Report of May/June 2010-2015 itemized some concepts in chemistry as areas commonly found difficult by students. These concepts are nuclear chemistry, organic chemistry, electrolysis, redox reactions, chemical equilibrium and rates of chemical reactions as the focused content in the present study.

Adesoji, Omilani and Dada (2017) opined that the failure to effectively grasp chemistry concepts makes students to have no option than to engage in rote memorization. In the same vein, students view chemistry as a difficult, complex and abstract subject that involves special intellectual ability and too much effort which makes them to have a poor grasp of chemistry concepts. Inability to grasp chemistry concepts, therefore, becomes a great challenge for them to study chemistry related courses at tertiary institution (Njoku & Nzewi, 2015).

Yusuf (2015) buttressed that most people held belief that knowledge of chemistry does not apply to daily life activities and this could result in psychological factor affecting the learning of chemistry. Similarly, WAEC Chief Examiner's report of

May/June 2009 clearly stated that students performed poorly in chemistry because of their inability to relate chemistry concepts to everyday life.

In the learning process, interest is germane to positive achievement. It is a motivating and crucial factor in learning process. Interest is a state of desiring to understand or learn something. Okoro (2013) suggested that the interest of a student can be determined by carrying out a survey through discussion and observing his or her activities. Okoro further stated that in selecting learning experience, it is natural for learners not to engage in what they are not interested in. Therefore, consideration of interest of the learners in order to achieve stated objectives of the lesson is very crucial. Ngwoke and Eze (2010) stated that direct interest in what is learnt by a learner stimulates the strength of the learners' ego and does not allow distraction by trivial events in the environment. Hence, it is peremptory to consider learners' interest during learning for laudable achievement.

Since it has been noted by researchers that that poor teaching method is one of the major problems of teaching and learning of chemistry, therefore computer-based concept and mind mapping strategies could be alternative and better ways of teaching and learning of chemistry in Nigerian senior schools. In teaching and learning process, concepts are very important. Concept and proposition are building blocks for knowledge in any domain. Concepts can be regarded as atoms of matter while propositions can be assumed to be molecules of matter (Novak & Canas, 2008). Students have many misconceptions in chemistry and find understanding of many concepts difficult because of the abstract nature of chemistry (Otor, 2013).

Literatures have shown that students do not organize their knowledge in such a way that it will stimulate and facilitate understanding. This results in inability in transferring previous knowledge to new knowledge (Eze & Onyenwe, 2018). Knowledge

can be mentally integrated through network mapping of concepts and their relationships. The mental externalizations are often called concept maps, mind maps, knowledge maps, vee maps, and argument maps (Richbourg, 2015).

In 1972, Joseph Novak, Professor Emeritus at Cornell University constructed concept maps through which he discovered development in the knowledge of children in science. Out of the necessity to find a better way to represent students' conceptual understanding emerged the idea of concept mapping. This concept has its roots from the constructivist leaning theory of Ausubel (Eze & Onyenwe, 2018). Asan (2007) defined Concept maps as "representations of concepts and their interrelationships that are intended to represent the knowledge structures that are in the minds" (p.186).

The concepts are embedded in circles or boxes with the use of linking words or phrases to link two concepts to show the connection among the concepts (Novak & Canas, 2008). Kilici and Cakmak (2013) categorized concept map into four different types: spider maps, hierarchical map, flow chart, system map and hierarchical map used in this study. These types of concept maps are distinguished by their ways of representing information.

Concept maps are not only visualized tools for representing concepts but also mind maps. Mind map is a graphic organizer of ideas and a visible drawing that indicates what happens in the process of storing information in brain (Mohammad, 2018). In 1960's mind maps were created by Tony Buzan who hailed from London (Ahmad, 2017). Mind maps are tools for representations that are constructed to represent an individual's, concepts and information about a certain topic in mind, using graphs, key words, images and diagrams in a two-dimensional environment to show relationship between them (Langley, 2019).

Chelsea (2020) categorized mind map into three basic types: Library mind maps, presentation mind maps and tunnel timeline mind maps. Library mind maps used in this study can also be referred to as reference maps. This type of maps is for organizing information for a clear and visual understanding of the subject without missing anything out. To create library maps, all information are put together and should be organized in a map tree.

The modern formalized mind mapping techniques are attributed to Tony Buzan whose technique involved the use of lines of differing thickness, colors, diagrams and pictures, as a method of knowledge memorization and recollection (Ahmad, 2017).

In the 21st century, a noticeable change is sweeping through the school system at all levels through the use of technological gadgets. Lina (2017) posited that 21st century learners are opportune to use all kinds of technological gadgets that could lead to quick access to new knowledge. The use of computer as one of the technological gadgets has become necessary for attainment of educational goals, development and advancement. Researchers have been interested in investigating and analyzing the effect of computer-based instruction which started to be used with the invention of computer as one of the most important technological devices of the time. Due to speedy advancement in information and communication technology, the utilization of computer in teaching and learning process has become absolutely necessary. The use of technology in education affords learners with a more suitable environment to learn, creates interest and student-centered atmosphere, and serves to promote students' motivation (Mohamad, 2018).

Computer-based instruction technique is a good example of integration of science and technology. The use of computer in the teaching and learning activities is defined as computer-based instruction (CBI). The traditional way of constructing concept maps and mind maps that uses chalk and chalkboard, paper and pencil can be replaced by the use

of computer. With the rapid development of information and communication technologies (ICTs), a number of computer-assisted concept and mind mapping system have been proposed. Programmes such as SemNet, Learning Tools, Inspiration, Mind Mapper, CmapTools, Mindomo, Freemind, Xmind, Popplet, Bubbl.U.s, Inspiration, MindMeister , Prezi and many others which enable learners to interrelate the ideas that they are studying in multidimensional networks of concepts and to label the relationships between all the ideas in the network (Beavers, 2014). Computer-based concept and mind mapping permit learners to modify maps of which are very difficult when using paper and pencil.

Despite the significance of chemistry to everyday life, the achievement and interest of students in the subject are influenced by several factors of which gender is one of them. Gender disparities have received attention of many researchers in science education because is one of the areas that gender differences are obvious. Comparisons of boys and girls have been carried out on variables such as achievement, interest, attitudes, perceptions, self-efficacy and motivation.

Okoli (2012) observed that women are under-represented in fields such as science, technology and engineering; even the few females that venture into such fields suffer discrimination in employment opportunities. Chinwe (2013) also discovered that there is still gender inequality in science enrolment, with females still enrolling less than males in the sciences. This difference was attributed to gender stereotyping in science which makes female students still consider science subjects as more suitable for males. However, Yusuf (2015) buttressed that attention has been on differences in the academic performance of adolescent males and females. It was discovered that recently girls are now performing better than boys that called for global need of strategies that can

improve literacy of boys. On the contrary, Chawla (2015) discovered that gender has no significant influence on students' performance and interest in science.

Since there is no consensus on whether gender has significant influence on students' performance and interest or not, there is the need to carry out more studies on the comparative achievement and interest of male and female students.

Students' achievement and interest based on different score levels (low, medium and high) can be influenced when exposed to a typical strategy. Adodo and Agbayewa (2011) defined score level as "a form of stratifying students into different categories on the basis of their perceived abilities and capacities for learning" (p. 48). Many studies have been carried out by researchers on score level which is synonymous to performance level to determine and find out which of the score levels benefits most when exposed to certain strategy. DeLacy (2004) opined that students of all ability levels benefit maximally from grouping that adjusts the curriculum to their aptitude levels.

Adodo and Agbayewa (2011) were of contrary opinion that ability grouping fails to benefit students as it ventures poor and minority students to low tracks where they receive a lower quality of instruction than their counterparts in higher ability levels, thus results to a widening of the achievement gap. Adebayo (2008) found out that the high scorers improved most, and then the average scorers and low scorers have the lowest mean score when exposed to concept mapping.

However, the findings of studies conducted based on score levels by Abdulwahab (2014) and Akanmu and Fajemidagba (2013) were not in line with Adebayo (2008). They observed no influence of score levels on achievement of students in chemistry and mathematics respectively. Hence, there is inconclusive consensus on the influence of score levels which is synonymous to performance level on the students' achievement. It is on this note that this present study investigated the influence of computer-based

concept and mind mapping strategies based on score levels on students' achievement and interest in chemistry.

Learning style has been recognized by researchers as one of the factors that influences students' achievement in science subjects. Learning style is the way and state under which learners prefer to process, store and recall information effectively and efficiently (Yabo & Nasiru, 2018). The learning style was classified as visual, auditory and kinesthetic. The visual learners can learn better by drawing a map, watch videos, use highlights, circle words, and note taking with symbols and pictures. Auditory learners can achieve better by recording lectures, group discussion, speaking and literary interpretation of analysis. Kinesthetic on the other hand achieve better by imagining body movement, constructing a product and making a game (Gopalakrishnan & Pazhalanivelu, 2017).

Several studies have shown that researchers held contradictory views on students' learning styles in relation to their achievement in chemistry and other science subjects. For instance, Alade and Ogbo (2014) posited that there is a significant relationship between learning style preferences of students and their performance in chemistry achievement test in both public and private schools. Idika (2017) also discovered that learning style has obvious impact on students' achievement in chemistry. Garner-O'Neale and Harrison (2013) contrastingly in their study of the relationship between learning styles and academic achievement observed that there was no significant difference between student's academic achievement and learning styles.

Statement of the Problem

Effective and appropriate teaching strategies can result into desired performance of students offering chemistry. Concept and mind mapping strategies have been found by educational researchers as effective strategies in addressing under-achievements in

chemistry (Ogbonna, 2014; Okeke, 2011). Concept mapping and mind mapping can be used as advanced organizers and strategies in the teaching of chemistry. They aid effective teaching as they give room for critical thinking.

Inconsistency in achievement of Nigerian students in chemistry in the Senior School Certificate Examinations (SSCE) has given rise to grave concerns for many researchers. The ugly trend of rise and fall in students' achievement in sciences particularly chemistry, has been attributed to many factors by many researchers. Prominent among these factors are poor teaching strategies (Omiko, 2017); students' lack of interest in the sciences (Okigbo, 2010); gender (Udo, 2011) and abstract nature of chemistry (Otor, 2013). The result of West African Senior School Certificate Examinations for May/June 2016 (WASSCE, 2016) in chemistry was below expectation with 57.74% credit pass and WAEC blamed it on lack of adequate understanding of some chemistry concepts.

The effects of concept mapping strategy have been studied alongside with other teaching methods by science educators. For instance, concept mapping and lecture method (Ahmad & Munawar, 2013), concept mapping and guided-discovery method (Fatokun & Eniayeju, 2014), concept mapping and guided-discovery (Oloyede, 2010), concept mapping and vee diagram (Polancos, 2012), but these researchers did not combine concept mapping and mind mapping in their studies and they were not computer-based. Also, none of these researchers combined gender, score level and learning style as their moderating variables. In Nigerian senior schools, the use of Computer-based mapping instructional strategy in the area of chemistry is rare (Abanikannda, 2015). However, it has been widely used and reported to be an effective teaching strategy to tackle students' poor performance in foreign countries such as

Turkey (Aydin, 2015), Iran (Bahadori & Gorjian, 2016), Qatar (Sabbah, 2015) and Jordan (Ahmad, 2017).

In view of the efficacy of computer-based mapping strategy, this study investigated the effects of computer-based concept and mind mapping strategies on the students' achievement and interest in chemistry considering gender, score level and learning style as moderating variables in order to cater for the gap in the literature.

Purpose of the Study

The main purpose of this study was to investigate the effects of computer-based concept and mind mapping instructional strategies on senior school students' achievement and interest in chemistry. Specifically, the study:

1. determined the difference in the achievement of students taught chemistry using Computer-based Concept Mapping (CCM), Computer-based Mind Mapping(CMM) and conventional teaching method;
2. established the effects of CCM, CMM and conventional teaching method on students' interest in chemistry;
3. established the effects of CCM instructional strategy on the achievement of male and female students in chemistry;
4. investigated the effects of CCM instructional strategy on the interest of male and female students in chemistry;
5. identified the effects of CMM instructional strategy on the achievement of male and female students in chemistry;
6. explored the effects of CMM instructional strategy on the interest of male and female students in chemistry;
7. examined the effects of CCM instructional strategy on low, medium and high scoring students' achievement in chemistry;

8. investigated the effects of CCM instructional strategy on low, medium and high scoring students' interest in chemistry;
9. examined the effects of CMM instructional strategy on low, medium and high scoring students' achievement in chemistry;
10. identified the effects of CMM instructional strategy on low, medium and high scoring students' interest in chemistry;
11. considered the effects of CCM instructional strategy on visual, auditory and kinesthetic learners' achievement in chemistry;
12. investigated the effects of CCM instructional strategy on visual, auditory and kinesthetic learners' interest in chemistry;
13. identified the effects of CMM instructional strategy on visual, auditory and kinesthetic learners' achievement in chemistry;
14. examined the effects of CMM instructional strategy on visual, auditory and kinesthetic learners' interest in chemistry;
15. investigated the interaction effects of CCM, CMM on gender, score level and learning style on students' achievement in chemistry;
16. probed the interaction effects of CCM, CMM on gender, score level and learning style on students' interest in chemistry;

Research Questions

In this study, the understated research questions were answered.

1. What difference exists in the achievement of students in chemistry when they are exposed to CCM, CMM and conventional teaching method?
2. What difference exists in the interest of students in chemistry when they are exposed to CCM, CMM and conventional teaching method?

3. What is the difference in the achievement of male and female students in chemistry when they are taught using CCM?
4. What is the difference in the interest of male and female students in chemistry when they are taught using CCM?
5. What is the difference in the achievement of male and female students in chemistry when they are instructed using CMM?
6. What is the difference in the interest of male and female students in chemistry when they are exposed to CMM?
7. What difference exists in the achievement of low, medium and high scoring students in chemistry when they are taught using CCM?
8. What difference exists in the interest of low, medium and high scoring students in chemistry when they are instructed using CCM?
9. What difference exists in the achievement of low, medium and high scoring students in chemistry when they are taught using CMM?
10. What difference exists in the interest of low, medium and high scoring students in chemistry when they are exposed to CMM?
11. What difference exists in the achievement of visual, auditory and kinesthetic learners in chemistry when they are taught using CCM?
12. What difference exists in the interest of visual, auditory and kinesthetic learners in chemistry when they are taught using CCM?
13. What difference exists in the achievement of visual, auditory and kinesthetic learners in chemistry when they are taught using CMM?
14. What difference exists in the interest of visual, auditory and kinesthetic learners in chemistry when they are taught using CMM?

15. Are there interaction effects of CCM, CMM on gender, score level and learning style on students' achievement in chemistry?
16. Are there interaction effects of CCM, CMM on gender, score level and learning style on students' interest in chemistry?

Research Hypotheses

The following null hypotheses were formulated and tested at .05 level of significance.

H₀₁: There is no significant difference among the achievement of students when exposed to CCM, CMM and conventional teaching method.

H₀₂: There is no significant difference among the interest of students in chemistry when taught using CCM, CMM and conventional teaching method.

H₀₃: There is no significant difference between the achievement of male and female students in chemistry when instructed using CCM.

H₀₄: There is no significant difference between the interest of male and female students in chemistry when taught using CCM.

H₀₅: There is no significant difference between the achievement of male and female students in chemistry when taught using CMM.

H₀₆: There is no significant difference between the interest of male and female students in chemistry when exposed to CMM.

H₀₇: There is no significant difference among the achievement of low, medium and high scoring students in chemistry when they are instructed using CCM.

H₀₈: There is no significant difference among the interest of low, medium and high scoring students in chemistry when they are taught using CCM.

H₀₉: There is no significant difference among the achievement of low, medium and high scoring students in chemistry when they are exposed to CMM.

H₀₁₀: There is no significant difference among the interest of low, medium and high scoring students in chemistry when they are instructed using CMM.

H₀₁₁: There is no significant difference among the achievement of visual, auditory and kinesthetic learners in chemistry when they are instructed using CCM.

H₀₁₂: There is no significant difference among the interest of visual, auditory and kinesthetic learners in chemistry when they are instructed using CCM.

H₀₁₃: There is no significant difference among the achievement of visual, auditory and kinesthetic learners in chemistry when they are instructed using CMM.

H₀₁₄: There is no significant difference among the interest of visual, auditory and kinesthetic learners in chemistry when they are instructed using CMM.

H₀₁₅: There are no significant interaction effects of CCM, CMM on gender, score level and learning style on students' achievement in chemistry.

H₀₁₆: There are no significant interaction effects of CCM, CMM on gender, score level and learning style on students' interest in chemistry.

Scope of the Study

The study was carried out in Ilorin metropolis of Kwara State and SSII Students offering chemistry constituted the target population. The reason for the choice of Ilorin metropolis was because, the two co-educational schools considered for the experimental groups must have well equipped computer laboratories, regular power supply or alternative supply of power in case of power outage. All these conditions seem to be met by schools in an urban area. Ilorin metropolis was also of interest because there was no evidence of study on effects of computer-based mapping strategies in the areas known to the researcher.

Senior School II chemistry students were appropriate since the chosen topic for the study is being taught in SSII. Also, the students in SSII were not preparing for any

external examination that may interrupt the conduction of the study. The content scope for the study was limited to the rates of chemical reactions. The moderating independent variables of this research were students' gender (female and male), students' score levels (high, medium, & low) and students' learning styles (visual, auditory and kinesthetic) while the dependent variables were students' achievement and interest scores.

Significance of the Study

The findings of this study are expected to immensely benefit the students, teachers, teacher educators, textbook writers, instructional material designers, policy makers, researchers, professional association, federal and state ministries of education.

The findings of this study could be of benefit to students being the first benefactor in having greater understanding and comprehension in the concept of rates of chemical reactions. Computer-based mapping strategies could assist students to learn meaningfully, create and use knowledge. This might enable students to identify concept meanings, relationships between concepts, rearrange the existing knowledge, organizing and understanding sequence and interconnectivity, relate new concepts to prior concepts, and to link learning with the taught pattern in the curriculum.

The concept maps and mind maps could also help students to be active because hands-on and mind on activities are the bedrock for concept mapping and mind mapping. When students are involved actively in the construction of maps, this might make them active as they sort out concepts and sub-concepts, they get a deeper and better understanding of the concept when map is drawn. It could give them ability to recognize it as learning strategy that gives them self-discovery and enhance their better performance in public examination. The concept and mind maps could also promote better knowledge organization in memory since they are capable of removing problem of overcrowding in students' memory working space which might aid better retention and

to learn how to learn by bringing to surface cognitive structure and self-constructed knowledge. Hence, findings from this study could influence students' achievement and interest in chemistry positively.

The results of this study could as well be of greater benefit to teachers in the choice of appropriate and effective innovative teaching strategies such as computer-based concept mapping and mind mapping in teaching chemistry. It might also assist chemistry teachers to save and manage their time properly as the use of maps gives summary of the main points of the concept and not only that but also it could encourage students to learn at their own pace and convenient time without the intervention of the teacher, while the teacher uses his time to embark on any other valuable activities.

Textbook writers could take the advantages of the findings of this study to simplify many concepts in chemistry by making use of concept maps and mind maps that would clearly spell out the relationships between concepts and therefore, correct misconceptions that students might have about rates of chemical reactions by writing new textbooks or reviewing existing ones. It could give insight to authors of textbooks the need to shift emphasis from teachers dominated activities to a more learner centered activities that involve concept maps and mind maps.

Similarly, the study could give an insight to teacher educators, the level of development of conceptual understanding in chemistry. It might give room for the advocate of computer-based instructional packages to be introduced and available in schools for learning.

Moreover, education researchers might also find the results of this study as a source of relevant literature in the field of chemistry education for further research works. It could also encourage other researchers to expand and carried out the same study with a larger scope and sample size in other locations.

Furthermore, policy makers could immensely benefit from findings of this study by emphasizing the importance of concept mapping and mind mapping in teaching chemistry. This could give insight on the need to produce a new generation of chemistry teachers who can successfully integrate ICTs, for instance, the use of computer in disseminating instructions in chemistry.

Instructional resources developers are likely to benefit significantly from the findings of this research as it will provide a framework for development of appropriate instructional materials that present sequence of instruction to students in a systematic way.

Findings of this study might provide a good reference point for both federal and state ministries of education in improving the performance of the students in chemistry. This could be achieved through organization and sponsorship of seminars and workshops for chemistry teachers and teacher training institutions on the use of innovative teaching strategies such as concept mapping and mind mapping in teaching and learning processes.

The professional association like Science Teachers Association of Nigeria (STAN) could be motivated by the findings of this study to organize workshops, seminars, conferences and in-service training on a regular basis to train teachers on the use of computer-based concept and mind mapping strategies.

The government could tremendously benefit from the findings of this study by gaining knowledge about the efficacy and effectiveness of computer-based mappings as innovative strategies. This might encourage government to promote innovative teaching strategies by supplying all the instructional materials needed by school for adequate teaching. For instance, distribution of computers to all secondary schools would aid computer-based instructions in teaching and learning of chemistry which could result in

attaining Nigeria's desire for scientific and technological breakthrough. The understanding of chemistry concepts is paramount to the attainment of Sustainable Development Goals (SDGs) and National Economic Empowerment Development Strategies (NEEDS).

Clarification of Major Terms and Variables

For the purpose of this study, the following terms and variables have been operationally defined.

Mapping strategy: It is the process of using map to represent the concept of rates of chemical reactions.

Concept-map: Hierarchical representation of concept of rates of chemical reactions.

Concept mapping: It is the process of constructing hierarchical representation of concept of rates of chemical reactions.

Mind map: Display of rates of chemical reactions in a visual representation using key words, pictures and colors.

Mind mapping: It is the process of displaying rates of chemical reactions in a visual representation using key words, pictures and colors.

Computer-based concept mapping strategy: It is the process of constructing hierarchical representation of concept of rates of chemical reactions to form meaningful propositions by using computer.

Computer-based mind mapping strategy: It is the process of displaying rates of chemical reactions in a visual representation using key words, pictures and colors by using computer.

Instructional strategies: Computer-based concept and mind mapping strategies to teach rates of chemical reactions.

Instructional package: This is the computer program developed to be used as instructional package to teach rates of chemical reactions in this study.

Conventional method: This is a method of teaching rates of chemical reaction without computer instructional package.

Interest: This is the students' positive or negative feelings and attitude towards chemistry when instructed using computer-based concept and mind mapping strategies.

Achievement: This refers to scores in Chemistry Achievement Test on Rates of Reactions (CATOROR) by the students who participate in the study.

Score level: Grouping of students based on their pre-test scores. It is of three categories of high (Pre-test scores that fall into 75th percentile), medium (Pre-test scores that fall into 50th percentile), and low (Pre-test scores that fall into 25th percentile).

Learning style: Senior school chemistry students' preferred way of learning rates of chemical reaction. This could be visual, auditory or kinesthetic.

Visual learners: These are learners that their preferred way of learning rates of chemical reactions is by seeing.

Kinesthetic learners: These are learners that their preferred way of learning rates of chemical reactions is by doing.

Auditory learners: These are learners that their preferred way of learning rates of chemical reactions is by hearing.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

The study reviewed the related literatures under the following subheadings:

- Theoretical Framework for the Study;
- Objectives and Content of the Nigerian Senior Secondary School Chemistry Curriculum;
- Factors Influencing Students' Achievement in Chemistry;
- Concept Mapping Instructional Strategy and Students' Achievement;
- Mind Mapping Instructional Strategy and Students' Achievement;
- Empirical Studies on Effects of Computer-based Concept and Mind Mapping Instructional Strategies on Students' Achievement;
- Influence of Students' Interest on their Achievement in Chemistry;
- Influence of Gender on Students' Achievement in Chemistry;
- Influence of Score Levels on Students' Achievement in Chemistry;
- Influence of Learning Styles on Students' Achievement in Chemistry; and
- Appraisal of the Reviewed Literature

Theoretical Framework for the Study

The conceptual understanding of chemical concepts such as rates of chemical reactions is acquired through theoretical foundation upon which this study is based. Abimbola (2017) defined theory as “a system of logical reasoning that scientists carefully construct, to explain the unknown natural phenomena, based on valid assumptions about them” (p.29). In other word, it is a way of providing explanation about phenomena.

In recent times, several efforts are being made by researchers and policy makers toward designing better strategies for effective teaching of science subjects especially chemistry, such include cooperative learning (Igboanugo, 2014); context-based strategy (Ogbu, 2012); problem solving (Igboegbu, 2013); constructivism (Eze, 2005) have been advocated. This study is based on constructivism which is applied to both learning theory and epistemology. Constructivism is a strategy of instruction and learning that involves interactive processes. Formal and informal learning sector are influenced by constructivist. It is thus a strategy of learning that has basis on the believe that knowledge is not a thing that can be given by the teacher in the class but rather, knowledge should be constructed by the learners through active mental processes such as construction of concept maps and mind maps.

In the view of Okoro (2013), constructivism is not a teaching theory but rather a theory of learning which emphasizes that human beings generate knowledge and meaning from interaction between their experience and ideas. Ekon (2016) added that learners are expected to be builders and creators of meaning of concepts and knowledge acquisition when they are given opportunity to be active in the classroom. Therefore, this involvement of learners in the class makes them to explore and manipulate learning tools such as computer in order to create knowledge.

Mayer (2004) buttressed constructive teaching/learning as active teaching/learning that shifts focus from the teacher to delivery of contents to the students with their active involvement in the class and engagement with teaching materials. Therefore, learning process is an interaction between mental schemes of the learners and features in learning environment which present study is concerned about. Constructive teaching strategies such as computer-based concept and mind mappings are based on constructivist learning theories of Jerome Brunner and David Paul Ausubel.

Brunner's theory of learning (1966) emphasizes the importance of discovery learning method in instruction. Brunner claimed that learning is facilitated when learner is able to figure things by him/herself. The theory emphasizes the role of human intellectual functioning and mental processes in learning. He pointed out two forms of discovery learning namely: assimilation and accommodation.

Ogbonna (2014) explained Brunner's theory as a theory that emphasizes that teachers will cause disequilibrium in the learners through learning materials and as the learner tries to resolve such disequilibrium he/ she makes some discovery through the process of cognitive restructuring by either assimilation of learning materials or accommodating it into his existing knowledge. Computer-based concept and mind mapping strategies are in line with Brunner's constructivist theory since these strategies are assumed to make learners to be actively involved in constructing their own meaning. The strategies present knowledge not as abstract and out-of context because of the flexible tool involved. Due to the nature of such constructed and authentic environment created by the flexible tool, it is assumed that the computer-based concept and mind mapping strategies can support construction of genuine knowledge via analysis, drawing of inferences both within text and beyond the text through connection with prior knowledge. The role of teacher in this theory is to act as a facilitator that would provide

flexible learning tools such as computer-based concept and mind maps that will enable learners to construct their own meaning resulting into better achievement as this theory supports.

Computer-based concept and mind mapping strategies are also based on Ausubel's (1963) assimilation theory of learning. The theory holds belief in meaningful learning rather than rote learning (Ausubel, 1963, Ausubel, 1968; Novak and Hanesian, 1978). Ekweoba (2014) explained that rote learning according to Ausubel occurs when no effort is made to connect new ideas with relevant existing ideas in cognitive structure, while the reverse is the case in meaningful learning. In meaningful learning, the learners integrate new concepts and propositions with existing relevant ideas. In this process, the learner builds his or her cognitive structure by assimilating new concepts into existing conceptual structure. The theory focuses on the fact that prior knowledge of the concept is a function of learning new knowledge which starts from cognizance and identification of events and object. Ausubel added that construction of a network of concepts aids learning. Thus computer-based concept and mind mappings are in line with this theory since they involve construction of network of concepts, visual representation of knowledge and improve recall. These strategies could be view as methodological tools of assimilation theory.

The framework of concepts and propositions organized hierarchically results in meaningful learning. In concepts and mind mappings, learners put new concepts into a larger, more inclusive category and then rearrange or restructure the new and old information as a whole. These strategies stimulate learners to be active in constructing new knowledge from existing one in his mind resulting into restructuring of knowledge.

Objectives and Content of the Nigerian Senior Secondary School Chemistry

Curriculum

Boundaries of the knowledge that learners are expected to acquire are the contents of the subject curriculum offered at the secondary school level. Therefore, students must have access to curriculum and instruction in order to achieve the stated objectives in the National policy on education (FRN 2013). The accessibility of students to curriculum and instruction is in line with the view of Yusuf (2015) about curriculum as the framework upon which teachers and students of a particular learning program depends on, so as to know what is required of them in terms of content, activities, instructional materials and evaluation that need to be inculcated in the teaching learning process.

Olorundare (2014) defined curriculum as the basic supporting structure for learning and its stand as a basis for what and how materials are to be learned by adopting a suitable and appropriate strategy that will result into effective teaching and meaningful learning process. The retention of every subject in the school curriculum depends on the extent to which the subject proves its usefulness (Abanikannda, 2015). Relevance of subjects in the curriculum calls for periodic review of the curriculum at all levels to meet the needs of society and the world of work as one of the stated specific goals of education in Nigeria (FRN, 2013). This is in line with the assertion of Okewande (2017) about curriculum as essential requirement developed around the culture of society, which students must imbibe.

It is the function of Nigerian Educational Research and Development Council to develop curricula to be used at all levels of education. It is against this background that the National Council on Education (NCE) in December 2005 mandated NERDC to review the existing Senior Secondary School Curricula in order to meet the targets of the

reform programs of National Economic Empowerment and Development Strategies (NEEDS) and Millennium Development Goals (MDGS). In January 2007 and March 2008, the NERDC convened a meeting of experts and stakeholders to produce Senior School Secondary Curriculum that focuses on the achievement of MDGS and important elements of NEEDS which can be summarized as value-reorientation, poverty eradication, wealth generation and using education to empower the people. The High-Level Policy Committee on Curriculum Development (HLPC) eventually came up with curriculum that represents the total experience to which all learners must be exposed, the contents, performance objectives, activities for both teachers and learners, teaching and learning materials and evaluation guide.

The curriculum for Senior Secondary Education consists of four fields of studies: (1.) Science and Mathematics (2.) Technology (3.) Humanities (4.) Business Studies. Science and Mathematics comprise of the following subjects: Biology, Chemistry, Physics, Further Mathematics, Health Education, Agriculture, Physical Education and Computer Studies. Chemistry in Nigeria as a country aspiring to be among the first 20 economies in the world by the year 2020 has the general objectives stated in Senior Secondary chemistry curriculum ranges from development of interest in the subject; acquiring basic theoretical and practical knowledge and skills; development of interest in science, technology and mathematics (STM); acquiring basic skills and knowledge in STM; development of reasonable level of competence in ICT application for entrepreneurial skills; applications of skills to meet societal needs of creating employment and wealth; positioning to take the advantages of the numerous career opportunities offered by Chemistry and to adequately prepare for further studies in chemistry (FME, 2009).

In view of the aforementioned objectives, stress on effective teaching of chemistry is of vital importance. Specific objectives also stated as: facilitation of smooth transition in the use of concepts and techniques acquire in the new Basic Science Technology Curriculum with chemistry; provision of basic knowledge in chemical concepts and principles through selection of contents and sequencing; showing chemistry and its inter-relationships with other subjects; showing links of chemistry with industry, everyday life activities and hazards and provision of complete course for students not proceeding to higher institutions and to bring about strong base for chemistry course in tertiary levels (FME, 2009).

Therefore, knowledge of students in understanding the basic concepts and principles specified in the chemistry curriculum could make individuals who offer chemistry at secondary education to attain self-fulfillment and become relevant members of the society. Senior secondary school chemistry curriculum is divided into four themes namely: Chemistry and industries, the chemical world, chemistry and environment and the chemistry of life.

Three issues namely: globalization, information and communication technology and entrepreneurship were taking into consideration in selecting the contents of the curriculum. This consideration anchors on the emphasis of the desire that Nigeria be identified with contemporary development worldwide. The curriculum is developed with contents that could eventually bring about self-actualization by students. It similarly focuses on practical activity that involves the local materials available within the environment of the learners in order to imbue the spirit of enquiry (FME, 2009).

The details of chemistry contents for the three years of senior secondary schools are as presented in Table 2.

Table 2

The Content of the Senior Secondary School Chemistry Curriculum

SS 1	SS2	SS3
Chemical industries	Periodic table	Qualitative and quantitative analysis
Introduction to Chemistry	Chemical reactions	Petroleum
Particulate nature of Matter	Mass-volume relationship	Metals and their compounds
Symbols, formulae and equation	Hydrogen	Iron
Chemical combination	Oxygen	Ethical, legal and social studies
Gas Laws	Halogens	Fat and oils
Standard separation techniques for mixtures	Hydrogen	Soap and detergents
Acids, bases and salt	Sulphur	Giant molecules (sugar, starch and protein)
Water	Oxidation-Reduction (Redox) Reactions	
Carbon and its Compounds	Ionic theory	
	Electrolysis	
	Hydrocarbon	
	Alkanols	

Source: NERDC, 2009: 30-38

A rate of a chemical reaction is a sub-topic under chemical reactions and it has been established by many researchers as abstract and difficult concept (Oyelekan, 2003; Kaya & Geban, 2011). Therefore, the effective strategies to handle it in the classroom setting that would aid students' conceptual knowledge rather than information

knowledge should be specified in the curriculum. All the general and specific objectives of senior secondary school chemistry curriculum could only be achieved through the innovative teaching strategies that stimulate positive impact in teaching and learning process. Hence, the adoption of computer-based concept and mind mapping strategies could be of great benefit to effective implementation of senior secondary school chemistry curriculum as well as in achieving the stated objectives.

Factors Influencing Students' Achievement in Chemistry

Many researchers have presumed some of the factors that influence students' academic achievement in chemistry. Ouma (2011) investigated factors influencing performance of students in Chemistry in public secondary schools in Kajiado North District, Kenya. The study covered the 17 public secondary schools in the District with a population of 2054 form 4 students. The research instruments used were questionnaires for teachers, students and class observation schedule. The study found out that one of the factors influencing students' performance was teaching and learning methods used by the chemistry teachers.

The study found out that lecture method, self directed learning/text books, class demonstration, homework drill and practices, assignment method, discussion method and practical work/ class experiment are methods used in teaching chemistry in public secondary schools. It was identified that the most often used means of teaching chemistry were lecture method, practical work/ class experiment and self directed learning/text books. The conclusion was made that teaching and learning methods influence students' performance in chemistry and that other teaching methods such as practical approach, class demonstration and field excursions which are more student involving for better academic results should be employed by teachers.

Ikechukwu and Akeem (2015) investigated factors influencing effective teaching of chemistry. The study showed that lack of adequate practical periods, inadequate laboratory facilities; inadequate relevant chemistry text books make the teaching of chemistry to be ineffective in most schools used for the study. The issue of lack of qualified and experienced teachers was not left out in the findings. The authors opined that most of the teachers handling the subject are not professional on the job, though they are graduates. The few qualified and experienced teachers only have few opportunity of attending in-service courses, workshops and seminars.

Ogembo, Otanga and Yaki (2015) carried out study on the level to which students' and teachers' attitudes serve as hindrances to students' achievement in chemistry in secondary schools. A sample of 482 students and nine chemistry teachers was used for the study. Results from the study indicated that poor performance of students in chemistry in Kwale County can be attributed to the teachers' negative perception of their learners' abilities. The recommendation was made that Chemistry teachers should organize excursions to chemistry-based industries in order to motivate the students to have positive attitude towards the subject and adoption of a more practical approach to the teaching and learning of chemistry by making use of instructional materials.

Ajayi and Ogbeba (2017) carried out study on the effects of gender on students' achievement in stoichiometry through the use of hands-on activities. It was established that significant difference did not exist between the mean achievement scores of male and female students when taught stoichiometry using hands-on activities. It was also discovered that significant interaction effect did not exist between the method and gender on mean achievement scores of students when taught stoichiometry. Recommendation

was given that both male and female students should be engaged in hands-on activities for better achievement in stoichiometry since the method is not gender biased.

Concept Mapping Instructional Strategy and Students' Achievement

Concept map is a model that represents knowledge and promotes the construction of a mental image of the information. It makes easier the visual identification of the most important concepts, the relationship between these concepts and their hierarchical organization. Schematic and organized ways of representing information provide students and teachers an effective tool to organize summarize and communicate their knowledge about any concept (Alfonso & Marta, 2014).

Concept maps are also graphic organizers that help students in organizing and representing knowledge to stimulate meaningful learning. They involve nodes (terms or concept) and linking lines with an arrow from one concept to another (Asiksoy, 2019). Concept mapping is a strategy that enables learners to identify the relationship between their prior ideas and arrange ideas in a logical construction (Novak & Gowin, 1984). This is in line with Ausubel's cognitive theory psychology which emphasizes that learning that is meaningful entails reorganization of existing beliefs or integration of new information with existing information.

Asan (2007) opined that "concept mapping is a method used to visualize the structure of knowledge and since knowledge in the maps is mostly semantic, concept maps are called semantic networks" (p.186). Concept map is often claimed to bear similarity to the structure of long term memory. Advantages of visual representation cannot be overemphasized. For instance, visual symbols are quickly and easily recognized with little effort. It also gives room for a total comprehension that ordinary words cannot deliver because the representation of parts and whole is in a successive order (Asan, 2007).

Concept mapping as an effective strategy claimed by science educators has been employed to allow teachers and learners to construct an organized knowledge in various topics in science disciplines (Chang, 2016). The educative use of concept mapping is not only to foster meaningful learning but also a motivator (Schaal, 2010). It motivates learners because of its capability for developing reflexive and collaborative learning. It is an appropriate strategy that permits a measure of conceptual understanding (Buehl & Fives, 2011).

Concept mapping is not only both effective learning and assessing tools but also increases learners' writing ability. Ebrahimi and Ebrahimi (2012a) affirmed that writing skill would improve if learners are able to relate new concept to their existing knowledge. Awareness of textual theme can also enable students to create cohesive texts. On the same note, concept mapping can be used as prewriting strategy for writing, which motivates students to "map out" their ideas prior to composing (Sinatara, 2000). It enables students to translate ideas and concepts using a visual graphical representation for writing assignment (Asiksoy, 2019)

Despite the educative significance effect of concept mapping to enhance meaningful learning, it has been critiqued by Sowa (2006) as being informal in his study on four different types of knowledge representation in which concept maps were one of them. Sowa claimed that although concept mapping can be constructed easily but they are informal in the sense that the maps made by different persons of the same domain do not match. The differences are as a result of different linking phrases that are chosen from natural language; meanwhile, the chosen concepts are mostly the same. Valery and Zoja (2015) also buttressed that the differences prevent concept maps from being suitable for a formal representation. Sowa however, claimed that informality makes them easy to be learned.

Concept mapping which is the unique way of representing information and a tool to teach critical thinking has been an important focus of many researchers. Several research studies conducted on concept mapping indicated that it is an innovative teaching strategy that has positive impact on both students' achievement and interest in chemistry.

Nwagbo and Okonkwo (2014) carried out study in Nnewi Education Zone of Anambra State, Nigeria to establish the efficacy of concept mapping on students' achievement in environmental concepts in chemistry. The study was a quasi-experimental with a sample size of 313 Senior Secondary two chemistry students randomly selected from four schools. The instrument used for data collection was Environmental Chemistry Concept Achievement Test (ECCAT). The ECCAT is 60-item 4 options multiple choice objective test developed by researchers. The analysis of pre-test and post-test was done using Mean, Standard deviation and Analysis of Covariance (ANCOVA). The study revealed that the students taught using concept mapping had higher achievement mean scores than students taught using lecture method. Therefore, concept mapping is significantly superior to the conventional lecture method. Concept mapping thus, demonstrated a greater understanding and comprehension of concept than lecture method.

Similarly, Oloyede (2010) compared the effect of the guided discovery and concept mapping teaching strategies on senior secondary school students' chemistry achievement. Four schools were selected from twenty-three (23) schools in Bauchi State, Nigeria. The instrument used was Chemistry Teacher Made Achievement Test (CMAT). The results of the study showed that there was a significant difference in the retention of the two groups in favor of the students taught using concept mapping. The results also showed that both the guided discovery and concept mapping are powerful in terms of

improving students' achievement in chemistry but concept mapping was more effective. Therefore, both teaching strategies are recommended for teaching chemistry.

Bamidele, Adetunji, Awodele and Irinoye (2013) conducted study on the attitudes of Nigerian secondary school chemistry students towards concept mapping strategies in learning the mole concept. The study compared the effectiveness of the use of different concept mapping strategies (hierarchical, flowchart and spider) used as advance organizers on student's performance and attitudes of students toward the use of concept mapping strategies. Research instruments used were Problem Solving Achievement Test in Chemistry (PSCATC) and Questionnaire on Attitude of Students towards Concept Mapping (QACSCM). It was discovered that no significant difference existed in the performances of the students exposed to the three strategies as well as the students' attitude to the concept mapping strategies. Therefore, it could be concluded from the study that concept mapping enhances students' performance and that any of the strategies could be used to support teaching of chemistry in the classroom. It could also be observed that concept mapping strategies are efficient in achieving instructional objectives that are related to cognitive and affective domains.

Ogbonna (2014) carried out study to investigate the effect of concept mapping on students' achievement and interest in selected concepts from organic chemistry. The study was a non-equivalent pretest posttest control group quasi-experimental design. The two instruments developed by the researcher; Organic Chemistry Achievement Test (OCAT) and Chemistry Interest Scale (CIS) were used to collect data for the study. It was found from the analysis that concept maps have statistically significant positive effect on students' achievement and interest in organic chemistry.

There were many studies that aimed to find out the effect of the concept maps in subjects other than chemistry. For instance, Awofala (2011) investigated the effect of

concept mapping strategy on achievement in mathematics. In the study, two schools were purposively sampled. Eighty-eight (88) Junior Secondary School III Nigerian students were sampled as the subjects. The study employed pretest-posttest non-equivalent control group quasi experimental design. The experimental group was taught with concept mapping and the control group was taught with conventional method. The instrument used for data collection was a Mathematics Achievement Test (MAT). The MAT was a 20-item multiple choice objective test constructed by the researcher to measure students' achievement in mathematics covering the selected topics covered in the study. It was eventually showed from the results of the study that the experimental group taught with concept mapping strategy obtained mean posttest score which was significantly higher than the mean posttest score of control group. This indicates that concept mapping strategy is an effective strategy for teaching mathematics.

Alebiosu and Michael (2011) conducted a study to investigate the effectiveness of using concept maps in improving the attitude of senior secondary students to physics. The design for the study was a pretest posttest control group quasi experimental design involving 2x2x3 factorial matrix. It also investigated the moderating effects of gender and quantitative ability. Ninety (90) Senior Secondary II students of intact classes in Ibadan Nigeria participated as subjects in the study. Three instruments used for data collection in the study were: 1. Teacher Instructional Guide (TIG) 2. Quantitative Ability Test (QAT) and 3. Physics Attitude Questionnaire (PAQ). QAT was administered for the classification of students into three quantitative ability groups of low, moderate and high. The PAQ was administered as pretest.

The students in experimental group were taught by using concept mapping strategy while the students in control group were exposed to conventional teaching method. The collected data were analyzed using Analysis of Covariance (ANCOVA). The

results showed that significant difference existed in post mean attitude scores of the students in favor of those taught with concept mapping. The implication is that teaching method has significant effect on the attitude of students to physics. However, the main effect of gender on student's attitude to physics was not significant. It was then concluded that concept mapping instructional strategy is more effective in improving students' attitude towards physics.

In a related study, Akeju, Rotimi and Keni (2011) investigated the effects of teaching with concept mapping instructional in Nigerian secondary schools. Quasi-experimental research design was adopted in the study. The sample consisted of 168 senior secondary school two students offering physics purposively selected from senior secondary schools across Ekiti State. Two instruments; motion concept map developed by the researcher and printed materials in the form of tutorial test items were used for data collection. Three hypotheses on the basis of achievement, retention of learned materials and attitude were tested. It was established from the result that concept mapping instructional strategy contributed positively to learning, achievement, student's retention of learned materials and students' learning attitude.

Sakiyo and Waziri (2015) also investigated the effects of concept mapping and inquiry teaching methods on secondary school students' academic achievement in biology. The total number of 176 senior secondary school two students was selected from three purposive selected secondary schools in Adamawa state. Biology Students' Achievement Test (BSAT) adapted from WAEC past questions 2005-2010 was used for data collection. ANCOVA was used to test the two hypotheses at .05 level of significance. It was discovered from the results that concept mapping, inquiry and lecture methods improve students' achievement in biology. The post hoc analysis established that concept mapping is better than inquiry and lecture while inquiry is better than lecture method. It

was then concluded that concept mapping and inquiry methods should be incorporated in the teaching of biology.

Studies on concept mapping were not limited to Nigeria but also in foreign countries. For instance, Chawla and Singh (2015) study was to determine the effect of teaching through concept mapping on achievement in chemistry among 9th Grade girls. The sample consisted of 118 girls of 9th class from two government schools of Ludihana city of India. Experimental group was exposed to concept mapping strategy while the control group was exposed to conventional method (lecture and discussion). Mixed Group Intelligence Test (MGIT) by Mehrotra (2008) was used to establish experimental equivalence. Achievement Test in Chemistry was used for data collection. The t-test analysis of the mean gain scores indicated that achievement of girls taught with concept mapping strategy was more significant than that of girls taught using conventional method. Therefore, Chawla and Singh, (2015) established the fact that concept mapping helps in easy understanding of concepts to the students and also helps to bring all desired effects in the field of education for better learning, performance and retention.

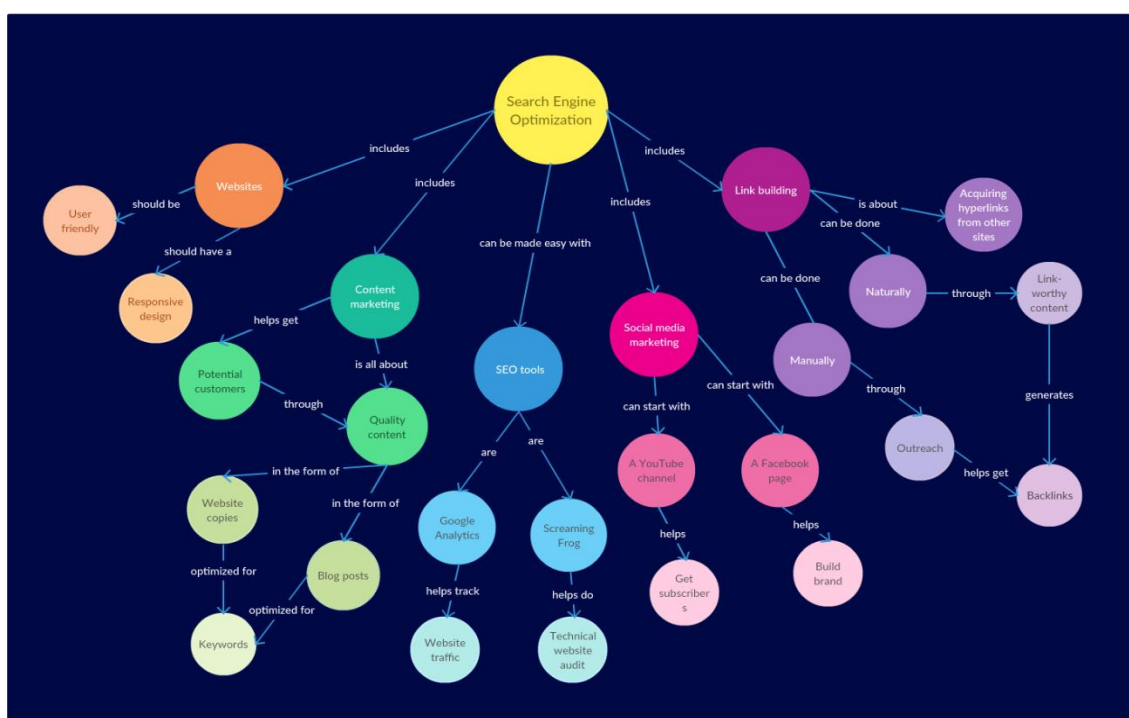


Figure 1: Example of Concept Map

Source: Retrieved from <https://creately.com/blog/diagrams/ultimate-concept-map-tutorial/>

Mind Mapping Instructional Strategy and Students' Achievement

Gargouri and Naatus (2017) defined mind maps as visual tools for developing complex conceptual structures displayed in a format that enables individual to utilize critical thinking and creativity to assimilate new information. The new information was described by Aydin (2015) as a topic or idea or concept displayed in a visual representation using key words, shapes and images.

Three conditions that must exist for meaningful learning to occur were stated by Ausubel (2002); (a.) identification of a relationship among the concepts to be learned by the learners (b.) the learners must possess specific relevant ideas (mind) to which this new material can be related and (c.) the learner must be able to relate constructed new ideas (mind map) to ideas already possessed (prior-knowledge). All these three conditions are incorporated in the process of mind mapping which makes it to enhance meaningful learning.

Mind mapping is effective since it enhances the skills associated with the brain. Okeke (2011) explained that brain has been the subject of research for many years and the results from studies have shown that brain is the most powerful computer. It is however estimated that only 1% of the potential of the brain is being utilized in our everyday activities. Within the millions of nerve cells in the brain, we have infinite potential waiting to be used.

Logue (2018) also claimed that mind map uses the right and left hemispheres of the brain to help generate ideas. The left side of the brain focuses mainly on the cortical words such as logic, lists, analysis and numbers while the right side of the brain focuses on such cortical words like rhythm, imagination, color, images, dimension and day dreaming. Therefore, the use of mind map becomes exciting in teaching and learning processes in the sense that it involves using color, images and key words within a mind map linking and associating. Mind mapping strategy in its effect uses both sides of the brain to enhance learning creativity and clarity of thinking to acquire scientific and technological knowledge.

Buzan (2011) enumerated necessary things needed to make a mind map as; blank unlined paper, colored pens and pencils, brain and Imagination. The author added that when mind map is used on daily basis, it would be found that life becomes more productive, fulfilled and successful on every level. There are no limits to the different ways by which mind maps could be of help.

Seven steps involved in making a mind map were enumerated by Buzan. These steps are: starting in the centre of blank page in order to give room for brain to expand in all directions; using an image or picture for the central ideas because an image is equivalent a thousand words which helps imagination and concentration; using colours throughout because colors are exciting to brain and add vibrancy to mind map which

appeals to aesthetic sensitivity that gives pleasure to brain in making mind maps; connect main branches to the central image and connect second and third level branches, first and second levels because brain works by association and it likes to link two or three things together to aid remembrance; making the branches curved rather than straight line because straight line is boring to the brain; using key words per line because single key words make mind map more powerful and flexible; and using images throughout because the use of image like the central image is equivalent to a thousand words, therefore, 10 images in a mind map amount to 10,000 words of notes.

Aydin (2015) also claimed that the brain is directed along a learning pathway by showing relationship and concepts together through key-words. The technique which Buzan expounded as using the brain totally was supported by other researcher such as Bahadori and Gorjian (2016). The author agreed that the mind mapping method as a learning technique stimulates and integrates functions on the left and right brain hemisphere processes at the same time. Moreover, Parikh (2016) pointed it out that mind mapping is an additional student aid because it is also an excellent note taking technique.

Benefits of mind maps could not be overemphasized as claimed by some researchers. For instance, Darren (2017) ascertained that mind mapping is a memory booster. Combination of imagery, color, visual-spatial arrangement has been proved to improve recall more than conventional methods of taking note and even learning by rote. Mind mapping also enhances learning because it brings about visual appeal through color, symbols and images and encourages students to make sense out of ideas by constructing them in a meaningful way. It helps students of various achievement levels to understand concepts and reason practically in accordance with the levels of their assimilation and ability to recall (Abi-El-Mona & Adb-El-Khalik, 2008). Parikh (2016)

also discovered that students found mind mapping to be great fun through lots of choice in color, symbols, key words and design.

Arulselvi (2017) opined that mind mapping strategy is a veritable teaching tool which allows teacher to identify effective teaching bearing when using it for lesson planning. The author added that mind mapping is a confidence booster in teaching as well as the facilitator of the smooth running of the lesson. Hence, mind mapping is very useful in the classroom because of it is a flexible strategy. Similarly, Nikhilkumar (2016) penned that the use of mind mapping as a teaching and learning strategy aids students' learning. This is due to the fact that mind mapping primarily helps them to develop sound categorization skills and then supporting them in depicting information within a visual format.

It has been evidently shown that mind mapping is a useful strategy for students in organizing and planning of their essays and project because it helps students in their written work to improve structurally and coherently (Khudhair, 2016). Mind mapping could therefore be used to plan and organize thinking before starting writing or getting stuck into a project. Ones' ideas could be developed using mind mapping and see where they relate to each other before decision on how to go about things.

Mind mapping is not only a useful technique for organization and planning but also an excellent tool for collaborating. Chang, Chiu and Huang (2018) found that students preferred to work with mind maps in teams. As a result of this, the students develop synergistic interaction, assemble collective knowledge and work with group minded attitude. Flowing of communication among group members also contribute to the creative process. Mind mapping also improves writing skills. Arulselvi (2017) revealed that students at all ability levels performed better in writing when using mind mapping for organization of ideas especially in pre-writing activity.

Boley (2008) stated that mind maps are relatively less known and used as an alternative creative technique to concept maps. The statement of Boley was challenged by Warwick and Kershner (2006), noting frequent instances of interchangeably in the use of both mind maps and concept maps. The authors claimed that in recent years, emphasis has moved from concept maps to mind maps which are two dimensional visual tools whereby a central idea or concept is visually linked to associated ideas or concepts.

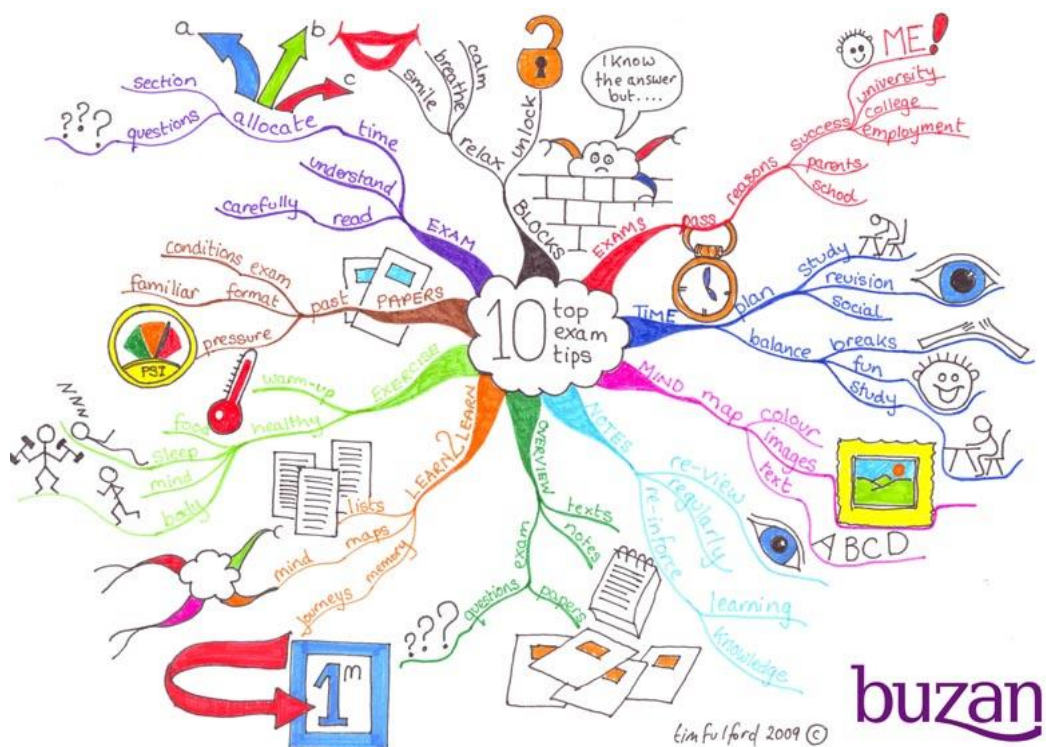


Figure 2: Example of Mind Map

Source: Buzan, (n.d). Retrieved from www.tonybuzan.com/gallery/mind-

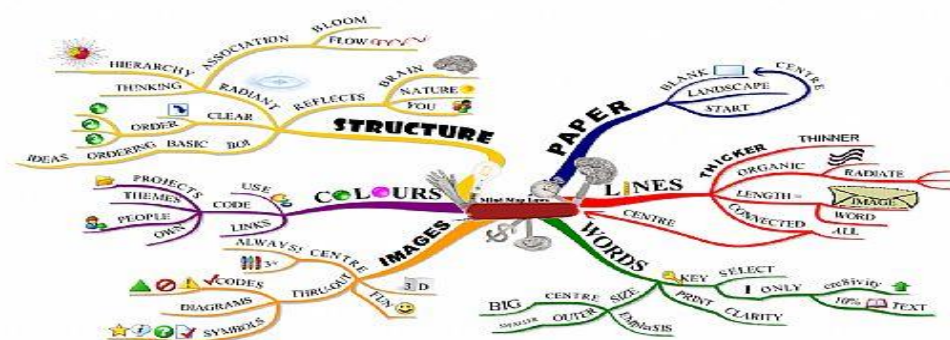


Figure 3: Example of Mind Map

Source: Buzan, (n.d). Retrieved from www.tonybuzan.com/gallery/mind-maps

Several researches have been conducted which are relevant to the present study on mind mapping instructional strategy. Such studies were not only restricted to chemistry. For an instance, Okeke (2011) examined the effect of mind mapping teaching strategy on students' interest and achievement in senior secondary school chemistry. A quasi experimental, non-equivalent non-randomized pretest posttest research design was adopted. The sample size was 194 SS2 chemistry students from Enugu Education Zone. Chemistry Achievement Test (CAT) and Chemistry Interest Inventory (CII) were the instruments used for collection of data. Mean and standard deviation were used to answer the research questions while the hypotheses were tested using Analysis of Covariance (ANCOVA). Results showed that student's interest, retention and achievement in chemistry were more facilitated when using MMTS than the conventional method.

In a related study by Bello and Oluwatosin (2014) to determine the effects of mastery learning and mind mapping approaches on achievement in physics: implication on gender and attitude. The sample for the study was 74 senior secondary school one (SS1) students offering physics from the three selected secondary schools in Ikere Local Government Area in Ekiti State, Nigeria. The instruments used for the collection of data were Physics Achievement Test (PAT) and Students' Attitude to Physics Questionnaire

(SAPQ). Analysis of the data was done using t-test and analysis of variance (ANOVA). The result of the study showed that no significant effect of treatment in the pretest and posttest scores of the male and female students when taught with the Mastering Learning Approach (MLA) and Mind Mapping Approach (MMA). The results also showed that the students taught with MMA developed a more positive attitude towards physics than students taught with MLA.

Studies have been conducted on mind mapping in foreign countries. For instance, a study was conducted in India by Nikhilkumar (2016). The study investigated the effectiveness of teaching through mind mapping technique. In the study, class-8th social science subjects' case study for mind mapping was designed. Two groups were involved in the study. Mind mapping technique was used to teach the experimental group while the control group was exposed to traditional method. The sample for the study was 120 students of Prena School, a Gujarati Medium High Elementary School in sector-6 of Gradhinagar, Gujarat. It was concluded from the results that the mind mapping strategy was more effective than traditional.

Akinoglu and Yasar (2007) in their study used mind mapping to investigate the effects of note taking in science education on students' attitudes, academic achievement and concept learning. Quantitative and qualitative research methods were adopted. In the quantitative area, the pretest posttest assessment was adopted with experimental and control groups. In the qualitative aspect, document analyses were made. The sample for the study was 81 6th grade students randomly selected from public schools in Faith Istanbul, Turkey. The results on the basis of data collected showed that there was a significant positive difference in students' concept learning, overcoming misconceptions, academic achievement and attitudes towards science courses by taking notes through the mind mapping technique.

Studies on mind mapping were not limited to sciences, for instance, Hallen and Sangeetha (2015) compared the effect of mind mapping technique with conventional method in teaching English using control and experimental groups. The sample consisted of 60 VIII standard students in Tiruchendur Talul in India. Mind maps and Achievement Test developed by the researcher were the instruments for the study. The pretest posttest experimental design was used in the study. Mean, standard deviation and t-test values were used for the analysis. The results of the study indicated that the mind mapping technique was more efficacious than the conventional method.

Empirical Studies on Effects of Computer-Based Concept and Mind Mapping

Instructional Strategies on Students' Achievement

Several Information and Communication Technology (ICT) tools are presently available in education for effective teaching and learning process. Ogunji (2013) defined ICT as “forms of technology that are used to transmit, store, create, share or exchange information, this includes technologies such as: radio, video, television, DVD, telephone (fixed and mobile phones), satellite systems, computer and network hardware and software, as well as the equipment and services associated with these technologies” (p.1).

ICT according to Adebisi and Adebisi (2016) is the emergence of tools of microelectronic and telecommunication which are utilized for analysis, automatic acquisition, storage, retrieval, manipulation, management, control, movement, display, transmission, reception and interchange of quantitative and qualitative data. Odekunle (2018) and Sulaiman (2010) opined that the elements of ICT include communication media (e.g. radio, television), information machine (e.g. computers) and telecommunications technologies and equipment (e.g. satellite, phones and facsimile machines). Ezekoka and Okoli (2012) classified the use of computer in education as; Computer Assisted Instruction (CAI), Computer Aided Instruction (CAI), Computer

Assisted Learning (CAL), Computer Based Education (CBE), Computer Based Instruction (CBI), and Computer Managed Instruction (CMI).

Computer based instruction (CBI) which is one of the most important technological devices of the time and the focus of this study has been defined by Serin (2011) as the use of computers in the teaching and learning activities. In spite of the value of the computer-based instruction in the classroom, the use of it is unusual in Nigeria (Fareo, 2013).

From the reviewed literature, it is necessary to state here that computer-based concept and mind mapping could also produce positive effects on students' interest and achievement in chemistry. The traditional approach to construct a concept map and mind map is to use paper and pencil. This paper and pencil approach has some limitations. The limitations such as; (a.) inconvenient for the interaction between the teacher and students in order to provide appropriate feedback (b.) it is very difficult to revise (c.) it is complex and difficult to construct and (d.) not efficient tool for evaluation (Abanikannda, 2015; Chang, 2016). The use of computer as a concept and mind mapping tool on the other hand provides timely feedback from the instructor to the respondents. The teacher can more effectively evaluate students' maps without the constraints of time and location (Aydin, 2015; Bahadori & Gorjian, 2016).

Several research studies conducted on computer-based concept and mind mapping strategies indicated that these are innovative teaching strategies that have positive influence on both students' achievement and interest in chemistry. Asan (2007) carried out study on the effects of incorporating concept mapping on the achievement in science class in Turkey. The test instrument used was a teacher-made multiple-choice test. In the experimental group, students were exposed to a short lesson in computer laboratory on concept mapping and the proper procedure for creating concept maps by using

Inspiration Program. Interview was also conducted on students' reaction to Inspiration Concept Mapping tool.

Findings from the study showed that experimental group performed in a statistically significant manner. The experimental group achieved a higher mean score in posttest. The t-test results indicated that the improvement in scores from the pretest to the posttest was significant. A large percentage of participants expressed that learning through the use of Inspiration Program was found enjoyable and easy process. In view of these findings, it could be concluded that computer-based concept mapping has a noticeable impact on students' achievement and reaction in science.

Chang, Sung and Chen (2001) compared the effectiveness of the 'construct- by - self,' 'construct on scaffold' and 'construct by paper-and-pencil concept mapping. Forty-eight seven-grade students, 23 females and 25 males were selected from three classes of one Junior High School in Taipei, Taiwan to participate in the study. The research employed a pre-post-test control group design. Biology achievement test of 23-item multiple choices was used as the test instrument. Two questionnaires were constructed to investigate students' opinions about concept mapping system and the 'paper-and-pencil' concept mapping method. The post-test scores of the three groups involved in the study were analyzed using Analysis of covariance (ANCOVA).

The results revealed that the posttest score of the 'construct-on-scaffold group was significantly better than those of the 'construct-by-self' and 'paper and pencil' groups. The results also showed that both of the two computer-based achieved more complete and accurate maps than the group using paper and pencil. Student's opinion on concept mapping strategies confirmed that all students in the 'construct-by-self' and in the 'construct-on-scaffold' groups expressed positive opinions on concept mapping as a useful strategy for biology learning. The majority were of opinion that concept mapping

could help them acquire the essential points of their learning materials while few students in the paper and pencil group believed that concept mapping was helpful to learning.

Chang (2016) in a related study investigated the effect of incorporating computer-based concept mapping in physics instruction. The sample for the study consisted of 61 9th-grade students from a public senior high school that is located in the northern region of Taiwan. The study adopted a quasi-experimental research design. The instrument; Work, Power and Energy Conception Test (WPECT) that consisted 32-questions multiple choice test was used for data collection and Analysis of Covariance (ANCOVA) was employed to analyze data. It was shown from the results that the Computer-Based concept Mapping (CBCM) group performed better than the No Concept Mapping (NCM) group in the conceptual understanding more obviously in higher order cognition. Therefore, the use of computer assisted concept mapping is advocated for science learning.

Aydin (2015) in a study investigated the effect of technology-supported mind and concept mapping on learning science concepts. The quasi-experimental design with a pretest posttest control group was used. The sample consisted of 62 sixth graders that were selected based on the pretest-score averages of “system in our body” concept test. The 6th graders were assigned into two experimental groups. Activities were carried out by students in experimental group 1 on “Support and Movement system, Circulation system and Respiration system” topics by preparing mind maps. Students in experimental group 2 executed similar activities by constructing concept maps on the same topic.

Students in experimental group1 made the mind maps in “Mind Manager Program” on computers while students in experimental group 2 made the concept map in

the “Inspiration Program”. The instrument used for data collection was a developed concept test. Quantitative data obtained from the concept tests were analyzed in Statistical Package for Social Science (SPSS). The result revealed that the students in experimental group 1 had a higher level of understanding concepts than the other groups. The students in experimental group1 affirmed that technology supported mind mapping was fun and instructive. The students in group2 also said technology supported concept mapping were fun and instructive.

Bahadori and Gorjian (2016) conducted study on the role of mind mapping software in developing English as a Foreign Language Learners (EFL). The study was conducted in a pre-university Centre in Masjedsoleyman, Iran. Out of 90 learners, 60 EFL learners were selected for the study. Homogeneity test was administered to choose the subject based on Interchange Language Placement test. The learners were assigned into two groups. The Mind mapping software (V3.5.3.0) from Xmind.net website was used to teach the experimental group lessons on vocabularies while the control group was taught using conventional method of instruction. Result revealed that the learners who were taught using the mind mapping software performed better than the control group. Therefore, mind mapping software which is synonymous to computer-based mind mapping serves as one of the innovative tools to help learners to achieve higher in their learning skills.

In order to further buttress the place of computer-based mind mapping on student’s learning achievement, Ahmad (2017) investigated the effect of using electronic mind mapping on achievement and attitudes in an introduction to Educational Psychology course. Electronic mind mapping instruction was employed to teach the experimental group and the control group was taught using traditional classroom instruction. The instruments used in the study were the achievement test and electronic

mind mapping attitude scale. The result of the study showed that significant difference existed between the two groups in achievement test scores in favor of experimental group that was exposed to electronic mind mapping.

In a related study, Sabbah (2015) investigated the effect of self-generated computerized mind mapping on students' reading achievement and their attitudes toward generating computerized mind maps for comprehension reading. The sample consisted of foundation-level students who were learning English language as a second language (ESL), in the community college of Qatar. The design of the study was quasi-experimental pre-posttest. The technique used to choose two ESL classes from five level three classes was convenience sampling. The experimental group of 14 subjects was taught reading text using students' self-generated computerized mind maps, while the control group of eight subjects was taught using teacher-generated whiteboard maps. Students' scores on the posttest were analyzed using ANCOVA. The result showed that there was significant difference in favor of experimental group. Questionnaire was also administered to identify the experimental group attitudes toward the treatment. The result also revealed positive attitudes of students to computerized mind mapping.

Concept map and mind map may be seen to be interchangeable, but there are some differences in the way they are created and used. Comparisons of the two types of map are shown in Table 3

Table 3

Comparison between concept maps and mind maps

Concept Maps	Mind Maps
Topics may have multiple parents	Topics may have a single parent and children
Formal attempt to organize or represent knowledge	Relative way to represent an idea or task.
They connect multiple ideas.	Focus on a central idea.
They are made with geometric shapes and straight lines	They are colorful, use wavy lines and often include pictures
Expand downward from the i.e. radial diagram.	Build outward from the centre i.e. top diagram.
Show systematic relationships among sub-concepts relating to one main concept.	Show sub-topic of a domain in creative and seamless manner
Good for classroom teaching, self-study and revision	Good for personal note taking and reviewing
Lack of flexibility	There is flexibility

Source: Clark (2011); Eppler (2006); Frey (2016)

Influence of Students' Interest on their Achievement in Chemistry

For meaningful understanding and assimilation of facts to occur in learning process, learners must show commitment and interest on the subject matter. It means that interest could be a condition in which learner is longing and having intention to learn about the subject matter. It implies that interest is intentional and not by force.

Okoyefi and Nzewi (2013) pointed out that students performed better when they are taught using method that can arouse their interest during teaching and learning process. Fairbrother (2000) opined that learners learn only when they want to learn. The

indication is that if students are not interested in science particularly chemistry they would not make an attempt to learn and understand the meaning of concepts that are being taught to them. Personal choice is one of the major factors contributing to declining students' interest in chemistry. Teachers are not the main source of dwindling students' interest toward chemistry; nevertheless students' interest could be motivated by using suitable educational techniques (Akram, Ijaz & Ikram 2017).

Oviawe and Lukman (2017) defined interest as interaction which is responsible for compelling a child to respond to a certain stimulus which is an aspect of affective domain. This implies that teaching approach that a teacher uses is an important factor that may motivate or mar students' interest in classroom activities. Students with intellectual capability may not learn until their interest is motivated through appropriate strategies.

Agbi (2006) opined that interest influences the achievement of student in chemistry. The author pointed out that interest engenders motivation and effort which combine together resulting in achievement and success in chemistry. Students' interest in chemistry was observed to be diminishing because of the use of non-innovative method of teaching. The interest of student that is low towards chemistry therefore could be as a result of conventional method of teaching being used in teaching chemistry. This situation calls for urgent and deliberate intervention in order to motivate students' interest in learning of chemistry. This could only be achieved through the use of innovative teaching strategies. Chemistry as one of the important science subjects to entire life of human races and nevertheless, student show little or no interest in the subject which in return brought about poor achievement.

Many studies have been conducted to bring about ways of ameliorate students' interest in chemistry. One of such studies is the one carried out by Okorie (2015), the

researcher ascertained the effects of instructional software package method of teaching (ISPMT) on student interest and achievement in chemical bonding. The population consisted of 5,966 senior secondary class1 (SS1) chemistry students in 57 senior secondary schools in Nsukka education zone of Enugu State, Nigeria. The sample consisted of 311 SS1 students that were purposively sampled. Students' Interest Scale on Chemical Bonding (SISCB) and Chemical Bonding Achievement Test (CBAT) were the instruments for data collection.

Descriptive statistics was employed to answer the research questions while Analysis of Covariance (ANCOVA) was used to test the hypotheses. Results indicated that the mean interest score of experimental group was higher than that of control group. This implies that, a type of stimulus that students are being exposed to, could determine their dispositions to learning.

In another development, Okeke (2011) carried out study on the effect of mind mapping teaching strategy (MMTS) on students' interest, retention and achievement in senior secondary school chemistry. The study adopted quasi-experimental, non-equivalent, non-randomized protest posttest research design. Two instruments used for data collection were Chemistry Achievement Test (CAT) and Chemistry Interest Inventory (CII). The research questions were answered using mean and standard deviation while ANCOVA was used to hypotheses at .05 level of significance. It was shown from the results that MMTS was more effective to facilitate students' interest, retention and achievement in chemistry than the conventional method. The indication is that the students' interest can easily be influenced and significantly sustained by the mode of instruction.

However, Udo and Udofia (2014) in their study investigated the effect of mastering learning strategy on student achievement in symbols, formulae and equation in

chemistry based on their interest. The instrument used was Students Interest Scale (SIS); a 20 item Likert scale developed for accessing students' interest in chemistry. The result revealed that student interest was not observed to be a significant determinant of students' performance in chemistry. This indicates that effect of interest on students' achievement is inconclusive, hence the need for present study.

Influence of Gender on Student's Achievement in Chemistry

The challenge that seems to have persisted for quite some time now is the question of female involvement in science and related subjects. It has been observed and established in literature that gender could be a strong influential factor to predict human behavior. The variations have been recorded between behaviors, attitude, interest and achievement of males and females (Aguale & Uhumuabi, 2008). Chang (2016) opined that gender is not enforced through law but it is based on self-perception and social institution. Gender disparity in education which is a worldwide phenomenon has become a great and global concern by many researchers. In relation to gender, studies have not been able to reach conclusion on the direction of difference in the academic performance. Some researchers were of opinion that boys performed better than girls while some established that female students performed better than male students.

Ifeakor (2005) investigated effects of commercially produced computer assisted instruction package (CPCAIP) on students' achievement and interest in chemistry. The study also investigated the effect of CPCAIP on gender as moderating variable. A total of 140 SS1 chemistry students from two private secondary schools were selected in Onitsha North and South Local Government Area of Anambra State. Analysis of the data obtained was done by using mean and standard deviation to answer research questions and ANCOVA was used to test the hypotheses at 0.05 level of significance. The result of

the study eventually revealed that gender was a significant factor in students' overall cognitive achievement in chemistry in favor of males.

Okeke (2011) examined the effect of mind mapping teaching strategy (MMTS) on students' interest, retention and achievement in senior school chemistry based on gender in Enugu education zone in Enugu state. The result revealed that there was significant gender influence on the mean achievement score of students taught using MMTS in favor of the females. The female students had the higher mean gain score. Udo and Udofia (2014) investigated the effect of mastery learning strategy on students' achievement in symbols, formulae and equations in chemistry considering gender as the variable. The sample consisted of 183 secondary school (II) chemistry students drawn from four intact classes from four out of fifteen co-educational schools in Nsit Ibom and Ibesikpo-Asutan Local Government Areas of Akwaibom State, Nigeria. The experimental group consisted of 43 male students and 49 female students while the control group comprised of 44 male students and 47 female students. The result showed that the male performed better than their female counterparts.

However, in a study conducted by Chawla (2015) on effect of concept mapping strategy on achievement in chemistry of IX Graders in relation to gender, the result revealed that boys and girls of experimental group do not differ in their achievement in chemistry. The sample size for the study was 236 (118 for experimental group and 118 for control group) IX class students from four government schools of Ludhiana city in India. The t-test statistics was employed to test the hypotheses. The findings revealed that no significant difference existed between the performance of male and female students.

From the reviewed literature, there are three categories of results on gender difference in achievement in chemistry. The first one is that in which significant gender

difference existed in chemistry achievement in favor of male students. The second category is that in which there is significant gender difference in chemistry in favor of female students while the third category is that in which no gender difference in chemistry achievement score is neither reflected in favor of the boys nor the girls. Therefore, it is obvious that there is an indication of inconclusive and inconsistent trend in gender achievement in chemistry. In view of this inconsistency and in conclusion, this study investigated effect of gender on chemistry achievement of students when taught using computer-based concept and mind mapping instructional strategies.

Influence of Score Levels on Students' Achievement in Chemistry

The prerequisite knowledge of students into any classroom instruction is very imperative. Many studies have shown that this prerequisite knowledge which is synonymous to score level influences students' academic achievement in sciences particularly in chemistry while others were of opinion that it has no influence. Therefore, score level on senior school students and their achievement in science has been an inconclusive view among researchers in their studies.

Lamidi, Oyelekan and Olorundare (2015) carried out study on the effects of mastery learning instructional strategy on senior school students' achievement in mole concept considering score level as moderating variable. A total of 60 students were in experimental group while the control consisted of 50 students. The students in each of the classes were grouped into three categories (high, medium, and low scorers) based on their cumulative score in chemistry in the previous school term. Analysis of Covariance (ANCOVA) was employed to find out whether the effect of mastery learning instructional strategy and the achievement scores of the students in chemistry co varied based of score levels of students. The result showed that significant difference existed among the achievement of high, medium and low scoring students that were taught using

the mastery learning instructional strategy. The students in the low score and medium score categories benefited more than their counterparts in the high score category.

Furthermore, Abanikannda (2015) in a study investigated the influence of score level on students' performance after exposure to the learning strategies. The study adopted a design-based research using the mixed-method approach and the sample consisted of one hundred and one students of senior school I offering chemistry. The study involved three groups (two experimental groups and one control group). The first experimental group was taught using computer-based hierarch concept mapping (CBHCMS) and second experimental group was taught using computer-based spider concept mapping strategy (CBSCMS) while the control group was taught using prepared instructional materials (PIM) in chemistry. The students in experimental group were categorized into three (high, medium and low). The influence of score level on the learning performance of students in both treatment groups was subjected to statistical analysis. The result of the analysis showed significant difference for students belonging to different score levels. Significant difference was established between high, medium, and low scorers in favor of high scorers.

Moreover, in another study, Adesoji, Omilani and Nyinebi (2015) on effect of homogenous and heterogeneous gender pair cooperative learning strategies on student achievement in chemistry at the secondary level. Students' mental ability which is synonymous to score level was considered as moderating variable which was classified into three levels of high, moderate and low. The study adopted a pretest-posttest, control group, quasi experimental research design. A total of three hundred students were randomly selected from six schools (two mixed schools, two boys' only schools and two girls' only schools) in Makurdi local Government Area of Benue State.

The findings of the study revealed that ability has a significant mean effect on student achievement. The students with high mental abilities benefited most from cooperative learning strategy especially those with the same gender pair. It was then recommended that further studies should be carried on how students with moderate and low mental abilities could benefit better to the level achieved by the high mental ability students. The present study also investigated the effects of score levels on students' achievement when taught using computer-based concept and mind mapping instructional strategies.

Influence of Learning Styles on Students' Achievement in Chemistry

Several researches have been conducted on the effects of learning styles on student's achievement in science and other non-science disciplines. The results of such studies remain inconclusive because the researchers hold contrasting views on learning styles in relation to students' achievement. Alade and Ogbo (2014) compared students' learning styles and their achievement in chemistry in selected public and private schools in Lagos metropolis. The research was a descriptive survey type with the sample size of 200 SS 2 Chemistry students. Chemistry Achievement Test (CAT) and the VAK Learning style Test (VLST) were the instruments used for data collection. Results from the study indicated that there was a significant relationship between learning style preferences of students and their performance in the chemistry achievement test in both public and private schools.

Olic and Adamov (2018) similarly investigated the relationship between learning styles and students' chemistry achievement. The sample size for the study was 265 second grade students (aged 15–16 years) from seven selected grammar schools in Vojvodina (Serbia). Chemistry knowledge test and Learning Style Inventory (LSI version 3.1) were the two instruments employed in the study to determine the learning

styles. One-way Analysis of Variance (ANOVA) was employed to test the difference in achievement between groups of students with different learning styles. The learning styles pinpointed were assimilating, divergent, convergent and accommodating. The results implied that there was a significant relationship existed between achievements and students' learning styles in chemistry.

Garner-O'Neale and Harrison (2013) on another note carried out study on the relationship between learning styles and academic achievement of students in chemistry at the University of the West Indies (the UWI), Cave Hill Campus in Barbados. The Paragon Learning Style Inventory which measures the four learning style dimensions; extrovert/introvert, sensate/intuitive, feeling/thinking and judging/perceiving was employed for data collection. Results from t-test statistics showed that no statistical significant difference existed in academic achievement of students based on learning styles.

Appraisal of the Reviewed Literature

This present study was meant to investigate the effects of computer-based concept and mind mapping instructional strategies on senior secondary students' achievement and interest in chemistry. The literature reviewed had been done by considering studies which are related to the present study.

Several studies reviewed in this study investigated the effect of concept mapping with other strategies such as demonstration (Fatokun & Eniayeju, 2014), lecture method (Chawla & Singh, 2015; Nwagbo & Okonkwo, 2014), inquiry teaching (Sakiyo & Waziri, 2015) and guided discovery (Oloyede, 2010). Most of these studies adopted pretest posttest control group quasi-experimental design which is similar to the present study. Nevertheless, none of these studies investigated the effect of concept mapping with mind mapping which was the focus of this study.

Studies reviewed for this study indicated that mind mapping enhances students' achievement and interest. None of these studies focused on computer-based mind mapping which is the focus of this study. Few studies on mind mapping that were computer-based have been undertaken in foreign countries, Turkey (Aydin, 2015), Iran (Bahadori & Gorjian, 2016), Qatar (Sabbah, 2015) Jordan (Ahmad, 2017) and none of these revealed the effect of computer-based mind mapping strategy on chemistry as a science subject. Aydin (2015) study that was based on science was on biology concepts and not chemistry.

The reviewed literatures showed that the computer-based concept mapping and mind mapping instructions improved the achievement of students in physics (Chang, 2016) and biology (Chang, Sung & Chen, 2001; Aydin, 2015). Is it therefore possible that mind map and concept maps could also have positive effect on students' achievement in chemistry? This was one of the questions this study provided answer to.

Based on the reviewed literature, differences in students' achievement in relation to gender has remained inconclusive since there is no agreement as to whether gender influences achievement in science or not. Some researchers observed that male students have higher level of achievement in science than female (Fatokun & Eniayeju, 2014; Ogbonna, 2014; Udo & Udofia, 2014). Others found out that female students achieve more than male students in science (Adebayo, 2002; Okeke, 2011). In the contrary, some few other studies in relation to gender found that gender had no impact on students' achievement (Chawla, 2015; Lamidi, Oyelekan & Olorundare, 2015; Olatoye, Aderogba & Aanu, 2011).

All these studies are related to this study because they were also carried out in science; however, they are different in respect to subject area, content and location. Moreover, Chawla, 2015; Bamidele, Adetunji, Awodele & Irinoye, 2013) were conducted in the

same subject area with the current study but none of them was computer-based concept and mind mapping strategies.

Researchers have identified score levels to have effects on students' achievement in science when taught using different instructional strategies. Some were of opinion that some strategies favored high scorers (Akanmu, 2013; Olaniyan, Omosewo & Nwakwo, 2015), while others were of contrary opinion that they favored the low and the medium (Abdulwahab, 2014; Gbigbaadua, Abimbola, & Ahmed, 2014; Lamidi, Oyelekan & Olorundare, 2015). As a result of inconsistency in the direction of difference in students' achievement in relation to score levels, this study stood to confirm whether computer-based concept and mind mapping strategies could influence students' achievement and interest in chemistry based on score levels.

Learning styles have been identified to have influence on students' achievement by researchers (Garner-O'Neale and Harrison, 2013; Olic & Adamov, 2018). Nevertheless, the type of learning style that is favored when taught students with different strategies has remained inconclusive.

In conclusion, reviewed literature seems to show that enough work has not been done on computer-based concept and mind mapping in chemistry particularly in Nigeria. Hence, the need for this current study cannot be overemphasized, as it would provide additional empirical evidence on the effects of computer-based concept and mind mapping instructional strategies on students' achievement and interest in chemistry considering moderating variables such as gender, score level, and learning style.

CHAPTER THREE

RESEARCH METHOD

The techniques and procedures that were used to carry out this study are presented under the following headings: Research Design, Population, Sample and Sampling Techniques, Research Instrument, Procedure for Data Collection and Data Analysis Techniques.

Research Design

This study employed a 3 x 2 x 3 x 3 pre-test, post-test, quasi-experimental, non-randomized control group design. The first three in the design indicates three groups (computer-based concept mapping, computer-based mind mapping and conventional method of teaching); the two indicates gender at two levels of male and female, the second three is students' score level at three levels of low, medium and high scorers while the last three stands for learning style at three levels (visual, auditory and kinesthetic). The design was chosen because it provides some degree of control for possible extraneous variables that might affect either the internal or external validity.

Two experimental groups and one control group were involved in the study. Students in the experimental group A were exposed to computer-based concept mapping (CCM) instructional strategy, the students in experimental group B were exposed to computer-based mind mapping (CMM) instructional strategy and the students in control group were exposed to conventional method of teaching. Intact classes were involved in the study in order to avoid disrupting of the regular school program. The independent variables in the study were computer-based concept mapping and computer-based mind mapping. The dependent variables were students' achievement and interest in chemistry while the moderating variables were the gender of the students, score level and learning style.

The layout of the design is shown below:

A: $O_1 X_1 O_2$

B: $O_1 X_2 O_2$

$O_1 \quad O_2$

Key:

O_1 = Pre-test for the three groups

O_2 = Post-test (reshuffled pre-test questions) for the three groups

X_1 = Treatment (CCM) for the experimental group A

X_2 = Treatment (CMM) for the experimental group B

Population, Sample and Sampling Techniques

The population for this study was all senior school students offering chemistry in Ilorin metropolis. The target population was all Senior School II (SSII) Students offering chemistry in Ilorin metropolis. The rationale for the choice of SSII was based on the fact that the content scope of the study is within the scheme of work for SSII students. Three co-educational senior schools were purposively selected out of 78 government senior schools in Ilorin metropolis. The preference for selecting co-educational schools was as a result of gender being one of the moderating variables in the study. The criteria for selecting the three schools were based on well-equipped computer laboratory (computer laboratory with all required software and hardware components that are compatible with the developed instructional packages (CCMIP and CMMIP), overhead projector, regular power supply and alternative supply of power in case of power outage) and exposure (Students and teachers' exposure to the use of computer in their schools). Random sampling technique was employed to assign the three schools into three groups. (Group

A, the Experimental group1; Group B, the Experimental group 2; and Group C the Control group).

Students from intact classes of SS2 offering chemistry from the selected three schools were stratified into score levels (high, medium and low) based on their performance in chemistry in the pre-test scores by using percentile, learning styles based on Visual, Auditory and Kinesthetic Learning Style Test (VLST) and along gender as male and female.

Research Instrument

The research instruments for this study comprised the following:

(i.) The treatment Instruments: The treatment instruments were Computer-based Concept Mapping Instructional Package (CCMIP) and Computer-based Mind Mapping Instructional Package (CMMIP). Each package contains five periods of 40 minute-lesson (two double periods and a single period).

The Computer-based Mapping Instructional Packages (CMIPs) were designed by the researcher in collaboration with a software developer. The packages were based on web 2.0 technologies, which are a mix of HTML5, JavaScript, JQuery Library and HTML5 Canvas technology. The interface of the CMIPs was developed with user interactivity in mind. The use of HTML5 and CSS3 were combined to give a responsive design of the interface. The coding was done using Adobe Dreamweaver CS6 software and Adobe Brackets Code editor, at every coding instance; preview was done using all kinds of browsers (e.g. Mozilla Firefox, Chrome and Opera)

JavaScript was used to handle the user end computation. The JQuery Library was used to add interactivities to the static HTML5 template that was initially designed for the package. The smooth scrolling was also achieved through the use of JavaScript. The coding was done likewise through the use of Adobe Dreamweaver CS6 software and

Adobe Brackets Code Editor, and the effect of each block of codes was previewed on the browser.

HTML5 Canvas was used for the responsiveness which includes the dragging, moving, zooming in and zooming out of the nodes and elements. It was also responsible for the adding and deleting of nodes.

The live coding effect was previewed locally using the Windows, Apache, MySQL and PHP (WAMP) server which was installed on the standalone system. The WAMP server combined both MySQL and PHP functions which enables them to be previewed on local devices using the local host: // protocol. Adobe Photoshop CS6 was also used for the graphical design of the packages. It was used in styling all the nodes, by adding the text colors, images, signs, objects and readings.

(ii.) Test Instrument: The test instrument that was used for collecting data was a researcher-developed Chemistry Achievement Test on Rate of Reactions (CATOROR) which comprised of 30 multiple choice objective items drawn from the topic; rates of chemical reactions, an aspect of senior school chemistry syllabus pertinent to the content area of the study. The items were structured to test students' knowledge, comprehension and application levels of rates of chemical reactions in chemistry based on Bloom's taxonomy of educational objectives.

(iii.) Chemistry Interest Scale (CIS): This is a researcher-developed 20-item interest scale. It has a 4-point, Likert-type response scale. The respondents indicated their degree of agreement and disagreement on a number of statements.

(iv.) Visual, Auditory and Kinesthetic Learning Style Test (VLST): This is an adapted test of 20 items with three options (a, b and c) to classify students into three learning styles. Options a, b and c represent visual, auditory and kinesthetic learners respectively.

The option that dominates indicates the learner's learning style. The VLST was modified to relate its content to chemistry learning and participants' environment.

Validation of Research Instrument

The validation of the treatment instruments (CCMIP and CMMIP) was done by two lecturers in the Department of Science Education, one lecturer in the Department of Chemistry, one lecturer in the Department of Educational Technology and one qualified secondary school chemistry teacher in Ilorin to determine the suitability in terms of language, durability, navigation, functionality, packaging, quality, appropriateness for learning, logic of arrangement of its content, emphasis on key concepts, illustration and use of color. The validators recommended among others that magnifier should be incorporated into CCMIP for boldness. Their suggestions and recommendations were strictly followed to amend the packages.

The instructional packages were trial-tested in two secondary schools in Ilorin metropolis which form part of research target population but did not take part in the actual study. It was during trial testing that the researcher discovered that the initial three periods allotted for the lessons were not sufficient. It was then changed to five periods.

The validation of Chemistry Achievement Test on Rate of Reactions (CATOROR), Chemistry Interest Scale (CIS) and VLST was done by two lecturers in science education and one chemistry teacher to assess the face and content validity of the instruments. All necessary corrections were taken into consideration.

Item analysis was carried out on CATOROR to ensure that each of the items was appropriate, and neither too difficult, nor too easy. This was done by computing the difficulty and discrimination indices. All the items with difficulty indices between 30-70% were considered to be appropriate while others below 30% and above 70% were discarded. Items with discrimination index of 0.3 or above were considered reasonably

well. Five questions (3, 8, 16, 21 and 27) were restructured due to results from item analysis.

The CATOROR was trial tested with students who were not involved in the research between the periods of three weeks using test-retest method. Pearson product moment correlation statistics was employed to establish reliability of CATOROR. The reliability value was 0.69 and the instrument was considered reliable. The reliability of CIS on the other hand, was determined using Cronbach's Alpha to determine the internal consistency of the items before the final administration. Cronbach's Alpha is appropriate because the responses to the items in the instrument are not dichotomous. The responses do not entail right or wrong, pass or fail answers but the level of agreement or disagreement with each given statement. The alpha value obtained was 0.73, and then the instrument was adjudged good for the purpose for which it was constructed. Cronbach's Alpha was also used to determine the internal consistency of the items of VLST and the alpha value obtained was 0.81.

Procedure for Data Collection

Before the data collection exercise, the researcher collected letters of introduction from the Head of Department, Department of Science Education, University of Ilorin to be given to the principals of selected schools seeking permission to involve their students and teachers in the study. The consent of parents of the students that participated in the study was also sought and researcher interacted with the students and enlightened them on the purpose of the study and that their activities would be treated anonymously and would be of great benefit to study of chemistry.

Similarly, the teacher's informed consent form was filled by the three participating chemistry teachers who served as the research assistants and facilitators to indicate their willingness in the study. The students were informed by the researcher that

their participations in the study would not be under coercion. Those who decided not to continue to participate in the study would be allowed to withdraw without any form of punishment in order to meet the standard of research practices. The students were assured not to be exposed to any hazards such as naked wires and other computer related injuries such as back and neck pain, headaches, shoulder and arm pain by providing comfortable sitting arrangement. Eyestrain was prevented by tilting or adjusting the brightness of computer screen. Not only that, but also a proper vision distance of 50cm to 100cm from the screen was maintained.

The experiment lasted for three weeks. The first week was used for the training of the selected chemistry teachers who assisted in the experimental groups using CCMIP of hierarchical type of concept map and CMMIP of library type of mind map. Students in experimental groups were also trained on the use of the computer-based concept and mind mapping strategies as well as administering the pre-tests and VLST.

The second week was used to teach both experimental and control groups using two double periods of 80 minutes each and a single period of 40 minutes. The research assistant in experimental group A taught the students by using hierarchical type of computer- based concept maps on rate of chemical reactions while the students in experimental group B were taught using library type of computer-based mind maps. The research assistants in the two experimental groups projected the lessons with the aid of projector and the students simultaneously had access to the lessons through the desktop, laptop or tabletop and the students clicked along side with the research assistants in a progressive manner.

The control group was taught without computer-based instructional packages but with regular conventional method.

In the third week, CATOROR and CIS used in the pre-test, containing the same items were reshuffled to avoid familiarity with it and it was administered to the experimental and control groups after the treatment as post-tests.

Data Analysis Techniques

The data collected were analyzed using relevant descriptive and inferential statistics. The research questions were answered using mean and standard deviation. Analysis of Covariance (ANCOVA) was used to test the sixteen formulated hypotheses at .05 level of significance. Bonferroni procedure was employed for post hoc analysis to locate the direction where the significant differences occur. Statistical analysis was carried out on the platform of Statistical Package for Social Sciences (SPSS) version 20.0.

CHAPTER FOUR

DATA ANALYSIS AND RESULTS

In this chapter, the data collected were analyzed and the findings were presented based on the research questions and hypotheses generated in this study. There were sixteen research questions with sixteen corresponding hypotheses. All hypotheses were tested using ANCOVA.

Frequency and percentages were used to describe the demographic characteristics of the respondents. Table 4 shows that out of 239 subjects that participated in the study, 95 (39.75%) of the subjects were in Experimental group 1, 61 (25.52%) in Experimental group 2 and 83 (34.73%) in the Control group.

Table 4

Distribution of the Respondents Based on Group

Group	Frequency	Percentage (%)
Experimental 1	95	39.75
Experimental 2	61	25.52
Control	83	34.73
Total	239	100.00

Table 5 shows that 127 (53.14%) of the subjects were males and 112 (46.86%) were females. This indicates that the male participants were more than their female counterparts.

Table 5

Gender Distribution of the Respondents

Gender	Frequency	Percentage (%)
Male	127	53.14
Female	112	46.86
Total	239	100.00

Research Question 1: What difference exists in the achievement of students in chemistry when they are exposed to CCM, CMM and conventional teaching method?

Research Hypothesis 1: There is no significant difference among the achievement of students when exposed to CCM, CMM and conventional teaching method.

The results from the analyses on the hypothesis one are indicated in Table 6, 7 and 8.

Table 6 reveals that the experimental group2 taught using CMM had higher mean achievement score ($\bar{x} = 15.23 \pm 3.08$) followed by the experimental group 1 taught using CCM strategy ($\bar{x} = 14.13 \pm 4.11$), while the control had ($\bar{x} = 11.05 \pm 3.30$) which showed that CMM instructional strategy has the highest mean value and is superior to CCM and conventional teaching method.

Table 6

The Posttest Achievement Mean Scores of Experimental and the Control Groups

Group	N	Mean	Standard Deviation
Experimental 1 (CCM)	95	14.13	4.11
Experimental 2 (CMM)	61	15.23	3.08
Control	83	11.05	3.30
Total	239	13.34	3.98

Analysis of Covariance was performed to determine the effects of computer-based concept and mind mapping strategies on students' achievement. Table 7 shows $F_{(2, 235)} = 42.75$, $p < .05$. Hypothesis 1 therefore, is rejected since p -value .00 is less than .05 alpha levels. This implies there was a significant difference in the achievement means scores of the three groups in favour of those taught using CMM strategy.

Table 7

Result of ANCOVA on the Posttest Achievement Mean Scores of the Two Experimental Groups and the Control Group.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1422.75 ^a	3	474.25	47.65	.00	.38
Intercept	1773.74	1	1773.74	178.22	.00	.43
Pretest	710.28	1	710.28	71.37	.00	.23
Groups	850.90	2	425.45	42.75	.00	.27
Error	2338.80	235	9.95			
Total	46286.00	239				
Corrected Total	3761.55	238				

a. R Squared = .38 (Adjusted R Squared = .37)

The result of the post hoc using Bonferroni as reflected in Table 8 indicated that there is difference. The result shows that those taught using CMM were better statistically than those who were taught using either the CCM or those who were taught using conventional teaching method. Also, those taught using CCM were better than those taught using conventional teaching method.

Table 8

Post-hoc Analysis of Mean Achievement Scores Comparison of the Two Experimental Groups and the Control Group.

(I) Groups	(J) Groups	Mean Difference (I-J)	Std. Error	Sig. ^b	95% Confidence Interval for Difference ^b	Interval for
					Lower Bound	Upper Bound
CCM	CMM	-1.62 [*]	.52	.01	-2.87	-.36
	Control	3.12 [*]	.47	.00	1.98	4.26
CMM	CCM	1.62 [*]	.52	.01	.36	2.87
	Control	4.74 [*]	.54	.00	3.44	6.03
Control	CCM	-3.12 [*]	.47	.00	-4.26	-1.98
	CMM	-4.74 [*]	.54	.00	-6.03	-3.44

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Bonferroni

Research Question 2: What difference exists in the interest of students in chemistry when they are exposed to CCM, CMM and conventional teaching method?

Research Hypothesis 2: There is no significant difference among the interest of students in chemistry when taught using CCM, CMM and conventional method of teaching.

The results from the analyses on the hypothesis two are indicated in Table 9, 10 and 11.

Table 9 reveals that the experimental group1 taught using CCM had higher mean interest score ($\bar{x} = 60.54 \pm 8.05$) followed by the experimental group 2 taught using CMM strategy ($\bar{x} = 60.34 \pm 7.86$), while the control had ($\bar{x} = 55.28 \pm 11.99$) which showed that CCM instructional strategy has the highest mean value and is superior to CMM and conventional teaching method on the basis of interest.

Table 9

The Post Interest Mean Scores of Experimental and the Control Groups

Groups	N	Mean	Standard Deviation
Experimental group 1 (CCM)	95	60.54	8.05
Experimental group 2 (CMM)	61	60.34	7.86
Control	83	55.28	11.99
Total	239	58.66	9.84

Analysis of Covariance was performed to determine the effects of computer-based concept and mind mapping strategies on students' interest in chemistry. Table 10 shows $F_{(2, 235)} = 12.06$, $p < .05$. Hypothesis 2 therefore, is rejected since p -value .00 is less than .05 alpha level. This implies there was a significant difference in the interest means scores of the three groups in favor of those taught using CCM strategy.

Table 10

Result of ANCOVA on the Post Interest Mean Scores of the Two Experimental Groups and the Control Group.

Source	Type III Sum of Squares	<i>df</i>	Mean Square	<i>F</i>	Sig.	Partial Eta Squared
Corrected Model	17082.33 ^a	3	5694.11	224.24	.00	.74
Intercept	451.36	1	451.36	17.78	.00	.07
Pre Interest	15624.80	1	15624.80	615.33	.00	.72
Groups	612.19	2	306.09	12.06	.00	.09
Error	5967.22	235	25.39			
Total	845478.00	239				
Corrected Total	23049.55	238				

a. R Squared = .74 (Adjusted R Squared = .74)

The result of the post hoc using Bonferroni as reflected in Table 11 indicated that there are differences. The result shows that those taught using CCM were better statistically than those who were taught using either the CMM or those who were taught using conventional teaching method. Also, those taught using CMM were better than those taught using conventional teaching method on the basis of interest.

Table 11

Post-hoc Analysis of Mean Interest Scores Comparison of the Two Experimental Groups and the Control Group.

(I) Groups	(J) Groups	Mean Difference (I-J)	Std. Error	Sig. ^b	95% Confidence Interval for Difference ^b	
					Lower Bound	Upper Bound
CCM	CMM	-.85	.83	.92	-2.85	1.15
	Control	2.97*	.76	.00	1.13	4.81
CMM	CCM	.85	.83	.92	-1.15	2.85
	Control	3.82*	.85	.00	1.77	5.87
Control	CCM	-2.97*	.76	.00	-4.81	-1.13
	CMM	-3.82*	.85	.00	-5.87	-1.77

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Bonferroni.

Research Question 3: What is the difference in the achievement of male and female students in chemistry when they are taught using CCM?

Research Hypothesis 3: There is no significant difference between the achievement of male and female students in chemistry when instructed using CCM.

In order to determine whether there is significant difference in the achievement mean scores of male and female students in chemistry when taught using CCM. ANCOVA was used for the analysis. Table 12 shows $F_{(1, 92)} = 2.05$, $p > .05$. Hypothesis 3 therefore, is not rejected since p -value .16 is greater than .05 alpha level which means that there was no significant difference in the achievement of male and female students

when taught using computer-based concept mapping instructional strategy. This implies that computer-based concept mapping instructional strategy is not gender biased.

Table 12

Result of ANCOVA on the Posttest Achievement Mean Scores for the Experimental Group1 (CCM) based on Gender

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	410.08 ^a	2	205.04	16.06	.00	.26
Intercept	778.17	1	778.17	60.96	.00	.40
Pretest	397.42	1	397.42	31.13	.00	.25
Gender	26.20	1	26.20	2.05	.16	.02
Error	1174.40	92	12.77			
Total	20542.00	95				
Corrected Total	1584.48	94				

a. R Squared = .26 (Adjusted R Squared = .24)

Research Question 4: What is the difference in the interest of male and female students in chemistry when they are taught using CCM?

Research Hypothesis 4: There is no significant difference between the interest of male and female students in chemistry when taught using CCM.

In order to determine whether there is significant difference in interest mean scores of male and female students in chemistry when taught using CCM. ANCOVA was used for the analysis. Table 13 shows $F_{(1, 92)} = .15$, $p > .05$. Hypothesis 4 therefore, is not rejected since p -value .70 is greater than .05 alpha level which means that there was no significant difference in the interest of male and female students when taught using computer-based concept mapping instructional strategy. This implies that

computer-based concept mapping instructional strategy is not gender biased on the basis of interest.

Table 13

Result of ANCOVA on the Post Interest Mean Sores for the Experimental Group1 (CCM) based on Gender

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	4143.95 ^a	2	2071.98	98.07	.00	.68
Intercept	198.89	1	198.89	9.41	.00	.09
Pre interest	4141.84	1	4141.84	196.05	.00	.68
Gender	3.21	1	3.21	.15	.70	.00
Error	1943.67	92	21.13			
Total	354235.00	95				
Corrected Total	6087.62	94				

a. R Squared = .68 (Adjusted R Squared = .67)

Research Question 5: What is the difference in the achievement of male and female students in chemistry when they are instructed using CMM?

Research Hypothesis 5: There is no significant difference between the achievement of male and female students in chemistry when taught using CMM.

To ascertain whether there is significant difference in the achievement mean scores of male and female students in chemistry when taught using CMM. ANCOVA was used for the analysis. Table 14 shows $F_{(1, 58)} = .25, p > .05$. Hypothesis 5 therefore, is not rejected since p -value .62 is greater than .05 alpha levels which means that there

was no significant difference in the achievement of male and female students when taught using computer-based mind mapping instructional strategy. This implies that computer-based mind mapping instructional strategy is not gender biased.

Table 14

Result of ANCOVA on the Posttest Achievement Mean Scores for the Experimental Group2 (CMM) based on Gender

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	30.96 ^a	2	15.48	1.66	.20	.05
Intercept	1070.11	1	1070.11	114.97	.00	.67
Pretest	24.21	1	24.21	2.60	.11	.04
Gender	2.33	1	2.33	.25	.62	.00
Error	539.83	58	9.31			
Total	14719.00	61				
Corrected Total	570.79	60				

a. R Squared = .05 (Adjusted R Squared = .02)

Research Question 6: What is the difference in the interest of male and female students in chemistry when they are exposed to CMM?

Research Hypothesis 6: There is no significant difference between the interest of male and female students in chemistry when exposed to CMM.

In order to determine establish if there is significant difference in interest mean scores of male and female students in chemistry when taught using CMM. ANCOVA was used for the analysis. Table 15 shows $F_{(1, 58)} = 1.00$, $p > .05$. Hypothesis 6 therefore, is not rejected since p -value .32 is greater than .05 alpha level which means that there was no significant difference in the interest of male and female students when

taught using computer-based mind mapping instructional strategy. This implies that computer-based mind mapping instructional strategy is not gender biased on the basis of interest.

Table 15

Result of ANCOVA on the Post Interest Mean Scores for the Experimental Group2 (CMM) based on Gender

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	2248.40 ^a	2	1124.20	44.62	.00	.61
Intercept	151.25	1	151.25	6.00	.02	.09
Pre Interest	2213.09	1	2213.09	87.84	.00	.60
Gender	25.10	1	25.10	1.00	.32	.02
Error	1461.37	58	25.20			
Total	225837.00	61				
Corrected Total	3709.77	60				

a. R Squared = .61 (Adjusted R Squared = .59)

Research Question 7: What difference exists in the achievement of low, medium and high scoring students in chemistry when they are taught using CCM?

Research Hypothesis 7: There is no significant difference among the achievement of low, medium and high scoring students in chemistry when they are instructed using CCM.

The result of Analysis of Covariance (ANCOVA) in Table 16 shows that there was no significant difference in the achievement of students taught rates of chemical

reactions using CCM strategy based on score levels with the $F_{(2,91)} = .54$, $p > .05$. The p -value .59 is greater than .05 significant levels. This implies that there was no significant difference in the achievement of students on the basis of score level.

Table 16

ANCOVA Analysis of the Differences in the Achievement of High, Medium and Low Scoring Students Taught with CCM Strategy

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	397.84 ^a	3	132.61	10.17	.00	.25
Intercept	164.83	1	164.83	12.64	.00	.12
Pretest	162.28	1	162.28	12.45	.00	.12
Score level	13.96	2	6.98	.54	.59	.01
Error	1186.64	91	13.04			
Total	20542.00	95				
Corrected Total	1584.48	94				

a. R Squared = .25 (Adjusted R Squared = .23)

Research Question 8: What difference exists in the interest of low, medium and high scoring students in chemistry when they are instructed using CCM?

Research Hypothesis 8: There is no significant difference among the interest of low, medium and high scoring students in chemistry when they are taught using CCM.

Table 17 shows the result of Analysis of Covariance (ANCOVA) that there was no significant difference in the interest of students taught rates of chemical reactions using CCM strategy based on score levels with the $F_{(2,91)} = 1.61$, $p > .05$. The p -value .21

is greater than .05 significant level. This implies that there was no significant difference in the interest of students on the basis of score level.

Table 17

ANCOVA Analysis of the Differences in the Interest of High, Medium and Low Scoring Students Taught with CCM Strategy

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	4207.38 ^a	3	1402.46	67.88	.00	.69
Intercept	183.26	1	183.26	8.87	.00	.09
Pre Interest	4141.63	1	4141.63	200.45	.00	.69
Score levels	66.64	2	33.32	1.61	.21	.03
Error	1880.24	91	20.66			
Total	354235.00	95				
Corrected Total	6087.62	94				

a. R Squared = .69 (Adjusted R Squared = .68)

Research Question 9: What difference exists in the achievement of low, medium and high scoring students in chemistry when they are taught using CMM?

Research Hypothesis 9: There is no significant difference among the achievement of low, medium and high scoring students in chemistry when they are exposed to CMM.

Table 18 shows that $F_{(2, 57)} = 2.41$, $p > .05$. Hypothesis 9 therefore, is not rejected since p -value .10 is greater than .05 significant level. This implies there was no significant difference among the achievement means scores of high, medium and low scorers when taught using CMM. It shows that all the three levels of students benefited from CMM strategy.

Table 18

ANCOVA Analysis of the Differences in the Achievement of High, Medium and Low Scoring Students Taught with CMM Strategy

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	70.88 ^a	3	23.63	2.69	.05	.12
Intercept	196.42	1	196.42	22.40	.00	.28
Pretest	63.77	1	63.77	7.27	.01	.11
Score levels	42.25	2	21.13	2.41	.10	.08
Error	499.91	57	8.77			
Total	14719.00	61				
Corrected Total	570.79	60				

a. R Squared = .12 (Adjusted R Squared = .08)

Research Question 10: What difference exists in the interest of low, medium and high scoring students in chemistry when they are exposed to CMM?

Research Hypothesis 10: There is no significant difference among the interest of Low, medium and high scoring students in chemistry when they are instructed using CMM.

The result of Analysis of Covariance (ANCOVA) in Table 19 shows that there was no significant difference in the interest of students taught rates of chemical reactions using CMM strategy based on score levels with the $F_{(2,57)}=.63, p > .05$. The p -value .54 is greater than .05 significant level therefore, hypothesis 10 is not rejected. This implies that there was no significant difference in the interest of students based on score level.

Table 19

ANCOVA Analysis of the Differences in the Interest of High, Medium and Low Scoring Students Taught with CMM Strategy

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	2255.29 ^a	3	751.76	29.46	.00	.61
Intercept	135.86	1	135.86	5.32	.03	.09
Pre Interest	2140.70	1	2140.70	83.89	.00	.60
Score levels	31.98	2	15.99	.63	.54	.02
Error	1454.48	57	25.52			
Total	225837.00	61				
Corrected Total	3709.77	60				

a. R Squared = .61 (Adjusted R Squared = .59)

Research Question 11: What difference exists in the achievement of visual, auditory and kinesthetic learners in chemistry when they are taught using CCM?

Research Hypothesis 11: There is no significant difference among the achievement of visual, auditory and kinesthetic learners in chemistry when they are instructed using CCM.

Table 20 shows that there was no significant difference in the achievement mean scores of visual, auditory and kinesthetic learners exposed to CCM strategy, with the $F_{(2,91)}=1.75$, $P > .05$. The p -value .18 is greater than .05 significant level therefore, hypothesis 11 is not rejected. This implies that visual, auditory and kinesthetic learners achieved when taught using CCM strategy.

Table 20

ANCOVA Analysis of the Differences in the Achievement of Visual, Auditory, and Kinesthetic learners Taught with CCM Strategy

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	428.40 ^a	3	142.80	11.24	.00	.27
Intercept	790.17	1	790.17	62.20	.00	.41
Pretest	366.59	1	366.59	28.86	.00	.24
Learning style	44.52	2	22.26	1.75	.18	.04
Error	1156.08	91	12.70			
Total	20542.00	95				
Corrected Total	1584.48	94				

a. R Squared = .27 (Adjusted R Squared = .25)

Research Question 12: What difference exists in the interest of visual, auditory and kinesthetic learners in chemistry when they are taught using CCM?

Research Hypothesis 12: There is no significant difference among the interest of visual, auditory and kinesthetic learners in chemistry when they are instructed using CCM.

The results from the analyses on the hypothesis 12 are indicated in Table 21, 22 and 23. Table 21 shows the post interest mean scores across the three learning styles. The kinesthetic learners had higher mean interest score ($\bar{x} = 62.91 \pm 8.21$) followed by the visual learners ($\bar{x} = 59.85 \pm 8.47$), while the auditory learners had ($\bar{x} = 58.00 \pm 6.01$) which showed that the kinesthetic learners had the highest mean value; they benefited most from CCM on the basis of interest.

Table 21

Description of the Interest Mean Scores of Visual, Auditory and Kinesthetic Learners Taught with CCM

Learning Style	N	Mean	Standard Deviation
Visual	40	59.85	8.47
Auditory	21	58.00	6.01
Kinesthetic	34	62.91	8.21
Total	95	60.54	8.05

Table 22 reveals that there was a significant difference in the interest of students taught using CCM strategy based the learners' learning style with the $F_{(2,91)}=4.46$, $p < .05$. The p -value .01 is less than .05 significant levels; therefore, hypothesis 12 is rejected. This implies that there was a significant difference in the interest of students based on learning styles in favor of visual and kinesthetic learners over auditory learners.

Table 22

ANCOVA Analysis of the Differences in the Interest of Visual, Auditory, and Kinesthetic Learners Taught with CCM Strategy

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	4314.50 ^a	3	1438.17	73.81	.00	.71
Intercept	221.99	1	221.99		.00	.11
Pre interest	3968.71	1	3968.71	203.68	.00	.69
Learning styles	173.76	2	86.88	4.46	.014	.09
Error	1773.12	91	19.49			
Total	354235.00	95				
Corrected Total	6087.62	94				

a. R Squared = .71 (Adjusted R Squared = .70)

The result of the post hoc using Bonferroni as reflected in Table 23 indicated that there were differences. The result shows that the kinesthetic learners were better statistically than either the visual learners or the auditory learners on the basis of interest when taught using CCM. Also, the visual learners are better than the auditory learners when taught using CCM on the basis of interest

Table 23

Post-hoc Analysis of Mean Interest Scores Comparison of the Visual, Auditory and Kinesthetic Learners Taught with CCM

(I) Learning Style	(J) Learning Style	Mean Difference (I-J)	Std. Error	Sig. ^b	95% Confidence Interval for Difference ^b	
					Lower Bound	Upper Bound
Visual	Auditory	1.67	1.19	.49	-1.23	4.57
	Kinesthetic	-1.92	1.03	.20	-4.44	.60
Auditory	Visual	-1.67	1.19	.49	-4.57	1.23
	Kinesthetic	-3.60*	1.23	.01	-6.59	-.60
Kinesthetic	Visual	1.92	1.03	.20	-.60	4.44
	Auditory	3.60*	1.23	.01	.60	6.59

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Bonferroni.

Research Question 13: What difference exists in the achievement of visual, auditory and kinesthetic learners in chemistry when they are taught using CMM?

Research Hypothesis 13: There is no significant difference among the achievement of visual, auditory and kinesthetic learners in chemistry when they are instructed using CMM.

The results from the analyses on the hypothesis 13 are indicated in Table 24, 25 and 26.

Table 24 shows the post interest mean scores across the three learning styles. The

kinesthetic learners had higher mean interest score ($\bar{x} = 17.58 \pm 2.81$) followed by the

visual learners ($\bar{x} = 14.75 \pm 2.79$), while the auditory learners had ($\bar{x} = 14.47 \pm 3.15$)

which showed that the kinesthetic learners had the highest mean value; they benefited

most from CMM on the basis of interest. This implies that computer-based mind

mapping strategy have different effects on students with different learning styles in terms of interest.

Table 24

Description of Achievement Mean Scores of Visual, Auditory and Kinesthetic Learners Taught with CMM

Learning Style	N	Mean	Standard Deviation
Visual	32	14.75	2.79
Auditory	17	14.47	3.15
Kinesthetic	12	17.58	2.81
Total	61	15.23	3.08

Table 25 shows that there was a significant difference in the achievement of students taught using CMM strategy based on the learners' learning style with the $F_{(2,57)}=5.18$, $p < .05$. The p -value .01 is less than .05 significant levels; therefore, hypothesis 13 is rejected. This implies that there was a significant difference in the achievement of students based on learning style in favor of kinesthetic and visual over auditory learners.

Table 25

ANCOVA Analysis of the Differences in the Achievement of Visual, Auditory, and Kinesthetic Learners Taught with CMM Strategy

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	112.08 ^a	3	37.36	4.64	.00	.20
Intercept	1151.98	1	1151.98	143.15	.00	.72
Pretest	28.44	1	28.44	3.53	.07	.06
Learning Style	83.45	2	41.72	5.18	.01	.15
Error	458.71	57	8.05			
Total	14719.00	61				
Corrected Total	570.79	60				

a. R Squared = .20 (Adjusted R Squared = .15)

The result of the post hoc using Bonferroni as reflected in Table 26 indicated that there were differences. The result shows that the kinesthetic learners were better statistically than either the visual learners or the auditory learners on the basis of interest when taught using CMM. Also, the visual learners were better than the auditory learners when taught using CMM on the basis of interest.

Table 26

Post-hoc Analysis of Mean Achievement Scores Comparison of the Visual, Auditory and Kinesthetic Learners Taught with CMM Strategy

(I) Learning Style	(J) Learning Style	Mean Difference (I-J)	Std. Error	Sig. ^b	95% Confidence Difference ^b Lower Bound	Upper Bound
Visual	Auditory	-.02	.87	1.00	-2.15	2.12
	Kinesthetic	-2.95*	.96	.01	-5.32	-.57
Auditory	Visual	.02	.87	1.00	-2.12	2.15
	Kinesthetic	-2.93*	1.07	.03	-5.58	-.28
Kinesthetic	Visual	2.95*	.96	.01	.57	5.32
	Auditory	2.93*	1.07	.03	.28	5.58

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Bonferroni.

Research Question 14: What difference exists in the interest of visual, auditory and kinesthetic learners in chemistry when they are taught using CMM?

Research Hypothesis 14: There is no significant difference among the interest of visual, auditory and kinesthetic learners in chemistry when they are instructed using CMM?

Table 27 shows that there was no significant difference in the interest mean scores of visual, auditory and kinesthetic learners exposed to CMM strategy, with the $F_{(2,57)}=.07$, $p > .05$. The p -value .94 is greater than .05 significant level therefore, hypothesis 14 is not rejected. This implies that there was no significant difference in the interest of students based on learning style when taught using CMM strategy.

Table 27

ANCOVA Analysis of the Differences in the Interest of Visual, Auditory, and Kinesthetic learners Taught with CMM Strategy

Source	Type III Sum of Squares	<i>df</i>	Mean Square	<i>F</i>	Sig.	Partial Eta Squared
Corrected Model	2226.70 ^a	3	742.23	28.53	.00	.60
Intercept	134.92	1	134.92	5.19	.03	.08
Pre interest	2162.54	1	2162.54	83.11	.00	.59
Learning style	3.40	2	1.70	.07	.94	.00
Error	1483.07	57	26.02			
Total	225837.00	61				
Corrected Total	3709.77	60				

a. R Squared = .60 (Adjusted R Squared = .58)

Research Question 15: Are there interaction effects of CCM, CMM on gender, score level and learning style on students' achievement in chemistry?

Research Hypothesis 15: There are no significant interaction effects of CCM, CMM on gender, score level and learning style on students' achievement in Chemistry.

Table 28 shows no interaction effect existed among the treatments (CCM and CMM), students' gender, score level and learning style on students' achievement in chemistry with the $F_{(7,185)} = 1.03$, $p > .05$. The p -value .41 is greater than .05 significant level, therefore, hypothesis 15 is not rejected. Hence, interaction effect did not exist.

Table 28

ANCOVA Analysis of the Interaction Effects of Treatments, Gender, Score Level and Learning Style on Students' Achievement in Chemistry

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Squared	Eta
Corrected Model	1996.69 ^a	53	37.67	3.95	.00	.53	
Intercept	182.18	1	182.18	19.10	.00	.09	
Pretest	270.13	1	270.13	28.32	.00	.13	
Treatments * Score level * Learning style * Gender	69.06	7	9.87	1.03	.41	.04	
Error	1764.86	185	9.54				
Total	46286.00	239					
Corrected Total	3761.55	238					

a. R Squared = .53 (Adjusted R Squared = .40)

Research Question 16: Are there interaction effects of CCM, CMM, on gender, score level and learning style on students' interest in chemistry.

Research Hypothesis 16: There are no significant interaction effects of CCM, CMM on gender, score level and learning style on students' interest in chemistry.

Table 29 shows no interaction effect existed among the treatments (CCM and CMM), students' gender, score level and learning style on students' interest in chemistry with the $F_{(7,185)}=1.17$, $p > .05$. The p -value .10 is greater than .05 significant levels therefore, hypothesis 16 is not rejected. Hence, interaction effect did not exist.

Table 29

ANCOVA Analysis of the Interaction Effects of Treatments on Gender, Score Level and Learning Style on Students' Interest in Chemistry

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Squared	Eta
Corrected Model	18229.49 ^a	53	343.95	13.20	.00	.79	
Intercept	315.94	1	315.94	12.13	.00	.06	
Pre interest	13227.50	1	13227.50	507.69	.00	.73	
Treatments*Score level							
*Learning style *	31.34	7	4.476	.17	.99	.01	
Gender							
Error	4820.05	185	26.054				
Total	845478.00	239					
Corrected Total	23049.55	238					

a. R Squared = .79 (Adjusted R Squared = .73)

Summary of the Findings

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

1. There was a significant difference among the achievement of students in chemistry when exposed to CCM, CMM and conventional method of teaching in favor of those taught using CMM strategy.
2. There was a significant difference among the interest of students in chemistry when taught using CCM, CMM and conventional in favor of those taught using CCM strategy.
3. There was no significant difference between the achievement of male and female students in chemistry when instructed using CCM.
4. There was no significant difference between the interest of male and female students in chemistry when taught using CCM.
5. There was no significant difference between the achievement of male and female students in chemistry when taught using CMM.

6. There was no significant difference between the interest of male and female students in chemistry when exposed to CMM.
7. There was no significant difference among the achievement of low, medium and high scoring students in chemistry when they are instructed using CCM.
8. There was no significant difference among the interest of low, medium and high scoring students in chemistry when they are taught using CCM.
9. There was no significant difference among the achievement of low, medium and high scoring students in chemistry when they are exposed to CMM.
10. There was no significant difference among the interest of low, medium and high scoring students in chemistry when they are instructed using CMM.
11. There was no significant difference among the achievement of visual, auditory and kinesthetic learners in chemistry when they are instructed using CCM.
12. There was a significant difference among the interest of visual, auditory and kinesthetic learners in chemistry when they are instructed using CCM in favor of visual and kinesthetic learners over auditory learners.
13. There was a significant difference among the achievement of visual, auditory and kinesthetic learners in chemistry when they are instructed using CMM in favor of visual and kinesthetic learners over auditory learners.
14. There was no significant difference among the interest of visual, auditory and kinesthetic learners in chemistry when they are instructed using CMM.
15. There were no significant interaction effects of treatments on gender, score level and learning style on students' achievement in chemistry.
16. There were no significant interaction effects of treatments on gender, score level and learning style on students' interest in chemistry.

CHAPTER FIVE

DICUSSION, COCLUSION AND RECOMMENDATIONS

This chapter presents the discussion of findings, conclusion and recommendations based on the major findings from the study carried out. The discussion is based on the considered variables, such as the achievement, interest, gender, score level and learning styles of students.

Discussion

This study was conducted to investigate the effects of computer-based concept and mind mapping instructional strategies on senior school students' achievement in chemistry. Based on hypothesis one, students in the two experimental groups performed better than the control group. The result showed that students' achievement in CATOROR was better when taught using computer-based concept and mind mapping strategies. However, students exposed to computer-based mind mapping instructional strategy performed better than their counterparts in experimental group1 that were exposed to computer-based concept mapping instructional strategy.

This could be as a result of aesthetic feature of mind map that involves combination of pictures and colors to depict concepts. This finding is in line with findings of Ahmad (2017); Aydin (2015); Bahadori and Gorgian (2016) and Chang 2016. It can therefore, be submitted that computer-based concept and mind mapping strategies promote better understanding of scientific concepts.

The study revealed that students taught chemistry using computer-based concept and mind mapping strategies had higher interest mean scores than their counterparts taught with conventional method of teaching. This implies that exposing students to computer-based concept and mind mapping strategies motivated students' interest towards learning of chemistry. This is probably because computer-based mapping

strategies provided more conducive learning condition as the students learnt in ICT environment. The students were enthusiastic to learn through computer which provided them with graphic illustrations, the use of colors and images of concepts considered. This finding is in agreement with the findings of Okorie (2015); Okeke (2011) and Oviawe and Lukman (2017). However, the study by Udo and Udofia (2014) revealed that interest was not a significant determinant of students' achievement in chemistry.

On the basis of gender, the finding revealed that there was no significant difference in the achievement means scores of male and female and interest mean scores of male and female students when taught chemistry using computer-based concept and mind mapping strategies. This implies that both male and female benefitted from CCM and CMM. CCM and CMM also increased both male and female students' interest equally. This indicates that computer-based concept and mind mapping strategies are not gender biased on the basis of interest. Both the male and female had positive interest when taught chemistry with CCM and CMM. This implies that computer-based mapping strategies can be used in both co-educational and single sexed schools.

This finding corroborates the finding of Chawla (2015). However, this finding contradicts the finding of Abanikannda (2015) who found out that male students performed better than their female counterparts when exposed to computer-based hierarchy concept mapping strategy. It also contradicts the finding of Okoye, Okongwu and Ogechuwku (2015) who found that male students had higher mean interest scores than their female counterparts.

When the influence of score level on students' achievement and interest when exposed to computer-based concept and mind mapping strategies was examined, the results of analysis indicated that there was no significant difference in the achievement and interest of high, medium and low scorers in the two experimental groups. This

implies that students benefitted in terms of achievement and interest when exposed to CCM and CMM irrespective of their score levels. This finding is in line with the earlier finding of Adodo and Agbayewa (2011) who found out that science students' score level did not affect their achievement when exposed to teaching strategies. This finding is also in consonance with the finding of Jekayinfa (2019) who revealed that all categories of students (low, medium and high) benefited equally from Computer Video instruction (CVI) in the area of interest. On the contrary, Abanikannda (2015) and Lamidi, Oyelekan and Olorundare (2015) reported differences in the achievement scores of low, medium and high scorers when exposed to learning instructional strategies.

The influence of learning style on the achievement of students in both treatment groups was subjected to analysis; the analysis showed there was no significant difference for students belonging to different learning styles when exposed to CCM. This corroborates the earlier submission of Garner-O'Neale and Harrison (2013) that learning style did not have any influence on students' achievement.

Significant difference, on the other hand was established between visual, auditory and kinesthetic learners when exposed to CMM. Significant difference existed between visual and kinesthetic in favor of kinesthetic, while significant difference as well existed between visual and auditory in favor of visual. Therefore, the kinesthetic learners benefited most from the CMM followed by the visual learners, while the auditory learners were the least beneficiaries. The reason for this could be as a result of kinesthetic learners being active in operating computer during the lessons and the visual learners being captivated with pictures and colors of mind map.

The study also revealed that there was a significant difference in the interest of students when exposed to CCM, but no significant difference when exposed to CMM

based on different learning styles. Visual learners and kinesthetic learners in CCM group had higher interest mean scores than their auditory counterparts. This could be as a result of visual learners being motivated by graphic illustration of the map and the kinesthetic being impressed by the active exploration of computer during lessons. This is partly in consonance with Alade and Ogbo (2014) who found in their study that visual learning style was the most preferred learning style and performed better among the students of chemistry in both private and public schools in Lagos, Nigeria.

This study revealed no significant interaction effect of the strategies on gender, score level and learning style on the achievement of senior school students in chemistry. This implies that the interaction of strategies on gender, score level and learning style do not exist. That is, the combination of effects of the moderating variables did not in any way influence the students' achievement in the study. The influence was mainly as a result of the treatments. Similarly, the study revealed no significant interaction effect of the strategies on gender, score level and learning style on the interest of senior school students in chemistry. This implies that the moderating variables had no influence on students' interest but the influence was as a result of the treatments.

Conclusion

This study concluded that the computer-based mapping instructional strategies considered are effective and are better ways of learning. This is because the findings of the study have shown that students taught using Computer-based concept and mind mapping strategies performed better than those that were exposed to the conventional method of teaching. Thus, it can be deduced that the use of Computer-based Concept and Mind Mapping strategies improved students' achievement and interest in chemistry. This implies that the use of CCM and CMM are reliable and efficient ways of learning

chemistry concepts. The strategies motivated the students to learn because they are simple to use, user friendly and fascinating.

The study also concluded that gender had no significant influence on achievement and interest when taught chemistry using CCM and CMM. The study revealed that both male and female students benefited from the strategies. Individual students of different score levels benefited equally in terms of achievement and interest when exposed to CCM and CMM. However, high scoring students had higher means scores than medium and low scoring students. This implies that when using CCM and CMM, special consideration should be given to medium and low scoring students.

It was found that, when learning style was considered there was no significant difference for students belonging to different learning styles when exposed to CCM. However, reverse was the case for CMM group. Therefore, different learning styles of students must be given special attention when using CMM especially the auditory learners in order to control factors that could be responsible for the imbalance.

Recommendations

Based on the findings, the following recommendations were made:

1. Students should make use of concept and mind maps in note taking during chemistry lessons as the use of maps gives summary of the main points of the concept which stimulates quick assimilation.
2. Teachers should make use of mapping strategies as innovative teaching strategies in teaching difficult topics in chemistry for qualitative and effective teaching of chemistry in Nigerian senior schools.
3. Text books writers should make use concept and mind maps to simplify many concepts in order to correct misconceptions that students might have about some concepts in chemistry.

4. The use computer-based mapping strategies should be emphasized by teacher educators for pre-service teachers as a suitable classroom instructional strategy for teaching and learning of chemistry.
5. Policy makers should advocate for the need to produce a new generation of chemistry teachers who can integrate the use of computer into chemistry instructions in their policy making.
6. Curriculum developers should incorporate the use of computer based mapping strategies into the senior school chemistry curriculum to enrich quality of classroom instructions.
7. The use of computer-based mapping strategies by the teachers should be emphasized through organized seminars and workshops by federal and states ministries as well as professional association such as STAN in order to arouse students' interest in learning chemistry.
8. The government at all levels, concerned non-governmental organizations, parent teachers associations and other relevant stakeholders in education should ensure provision of functional computers and other useful facilities for the use of computer-based mapping strategies to enhance students' interest in learning chemistry.

Suggestions for Further Studies

The following were suggested for future research on computer-based concept and mind mapping strategies:

1. This study focused on the effects of computer-based mapping strategies on senior school students' achievement and interest in Ilorin, Nigeria. Similar studies can be conducted in other parts of Nigeria.
2. The focus of other studies may be on tertiary institutions rather than senior schools in Kwara state.

3. Further studies on the use of CCM and CMM should be carried out on difficult topics in other subject areas such as biology and physics.
4. Focus of other studies may be on other variables such as attitude, retention and motivation. Such variables on which the effects of CCM and CMM could be investigated rather than achievement and interest considered in this study.

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APPENDIX I

LESSON NOTES FOR EXPERIMENTAL GROUP 1

(COMPUTER-BASED CONCEPT MAPPING)

1ST PERIOD

Subject: Chemistry

Topic: Rates of chemical reactions

Class: SS2

Average Age: 16 years

Duration: 40 minutes

Reference Book: (i.) New School chemistry by O.Y Ababio (ii.) Chemistry for Senior Secondary Schools 2 by STAN

Instructional materials: Textbook and picture of two runners.

Behavioral Objectives: At the end of the lesson students should be able to:

- (i) define rates of chemical reactions
- (ii) calculate the rate of a given reaction
- (iii) explain the rate curve
- (iv) explain the collision theory

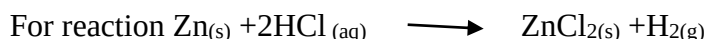
Previous Knowledge: Students have been familiar with types of reactions such as Oxidation, Reduction, Decomposition, Displacement, Double decomposition etc.

Introduction (5mins): Teacher introduces the lesson by asking the students to state some reactions that they know. Teacher then asks them to explain catalytic reaction. Teacher then explains that all runners start at the same time but it takes them different times to run the course. This is because they all run at different rates.

Presentation

Teacher's Activities (27mins)

Step 1: Teacher uses concept map to discuss the rate of chemical reaction with the students as the number of moles of reactant converted or product formed per unit time.



Teacher then uses concept map to discuss ways by which rate of reaction can be measured with the students. Rate of reaction can be measured by measuring the

- decrease in the mass of the reaction system
- volume of a gaseous product
- amount of precipitate formed
- time taken to arrive at an early seen stage
- changes in intensity of color
- changes in PH
- changes in total gas pressure

Step 2: Teacher uses concept map to discuss calculation on rate of a chemical reaction with the students.

Generally, reaction rate = $\frac{\text{Change in concentration of reactant/product}}{\text{Time taken for change}}$

The unit is g/min, cm²/min

Example: What is the rate of reaction when 0.5g of calcium trioxocarbonate(iv) was added to excess dilute hydrochloric acid, carbon(iv)oxide was evolved? The entire reaction took 5 minutes.

Solution:

Rate of reaction = $\frac{\text{Mass of reactant (CaCO}_3\text{)}}{\text{Time taken}}$

= $\frac{0.5\text{g}}{5\text{min}}$

= 0.1g/min

Step 3: Teacher uses concept map to discuss the rate curve with the students. The graph which shows the rate of reaction is known as rate curve. The curve passes through the origin because there is no loss in mass at the beginning of the reaction. The gradient of the curve measures how quickly the concentration is changing.

Gradient/slope = $\frac{\text{Adjacent}}{\text{Opposite}}$ is the reaction rate if a straight line or tangent at a

Point, if it is a curve. If the gradient is greater the rate is faster and the rate is slower by the small gradient.

Step 4: Teacher uses concept map to discuss collision theory with the students.

Ababio (2011) penned that “the collision theory assumes that there must be collision between reactant particles for a chemical reaction to occur and there are many such collisions, only a small fraction of them result in a reaction, this is called effective collision, therefore, for a reaction to occur the colliding reactant particles must possess a certain minimum amount of energy called **Activation energy**” (p.245). This is the energy barrier that must be overcome before bonds are stretched and sufficiently broken to enable the reaction take place. This reaction occurs if the energy of the colliding reactant particles is equal to or more than the activation energy. When this activation energy is acquired by the reactant particles then form a complex particle of high energy content. This high energy particle is known as activated complex.

Ababio (2011) further explained that “for a chemical reaction to occur, the minimum amount of energy possessed by the colliding reactant particles for a chemical reaction to occur is therefore, called activation energy and the collision theory can be used to explain how changes in temperature, concentration, nature of reactant and presence of the catalyst affect the rates of chemical reactions” (p. 253).

Student's Activities

- i. Students respond to teacher's questions on their previous knowledge.
- ii. Students participate in defining rates of chemical and mention different ways by which rate of a reaction can be measured by clicking the navigation words.
- iii. Students participate in calculating rate of a chemical reaction
- iv. Students listen attentively as the teacher explains the rate curve
- v. Students listen carefully as the teacher describes collision theory.
- vi. Students ask questions for better understanding of the topic

Evaluation (3mins): Teacher asks the following questions

- (i) What is meant by the rates of chemical reactions?
- (ii) Explain the term collision theory.
- (iii) Explain the term activation energy.

Conclusion (2mins): Teacher summarizes the whole lesson.

Assignment (3mins): Teacher asks the students to use collision theory to explain physical state and its effects on reaction rates.

2ND AND 3RD PERIODS

Subject: Chemistry

Topic: Factors that affect the rate of a chemical reaction

Class: SS2

Average Age: 16 years

Duration: 80 minutes

Reference Book:(i) New School Chemistry by O.Y Ababio (ii.) Chemistry for Senior Secondary Schools 2 by STAN

Instructional material: Text book and sugar (granulated and cube)

Behavioral Objectives: At the end of the lesson students should be able to:

- (i) explain nature of reactants as factor that affects rate of a chemical reaction.
- (ii) explain effect of change in pressure as factor that affects rate of a chemical reaction.
- (iii) explain effect of change in concentration as factor that affects rate of a chemical reaction.
- (iv) explain effect of light as factor that affects rate of a chemical reaction
- (v) explain effect of change in temperature as factor that affects rate of a chemical reaction.
- (vi) explain effect of surface area as factor that affects rate of a chemical reaction.

Introduction (4mins): Teacher introduces the lesson by making reference to collision theory of the previous lesson, that it can be used to explain how nature of reactant, changes in temperature, concentration, pressure and catalyst affect the rates of chemical reactions.

Presentation (56 mins)

Teacher's Activities

Step 1: Teacher guides the students by using concept map to discuss nature of reactant as a factor affecting the rates of chemical reactions. The rate of a chemical reaction of substances is a function of their chemical nature because they have different energy contents.

For instance, when a piece of iron is placed in dilute hydrochloric acid, there is a slow evolution of hydrogen gas, with a piece of zinc, hydrogen is evolved rapidly and with a piece of gold, there is no evidence of a reaction.

Step 2: Teacher initiates class discussion on effect of concentration of reactants by using concept map. Reactant particles will collide more often if they are crowded in a small space i.e. frequency of collision is dependent upon concentration. The effective collisions of the reactant and the reaction rate increases or decreases with equivalent increase or decrease in concentration of reactants.

Step 3: Teacher uses concept map to discuss effect of change of pressure for gasses with the students. Pressure affects the concentration of gaseous reactants. For example, a mixture of hydrogen and chlorine gasses will react twice as fast if the partial pressure of hydrogen or chlorine is increased from 0.5 to 1.0atm. The concentration of solid and liquid is unaffected by changes in pressure. In general, reaction rate decreases with time. This is because as reaction goes on the reactant are being used up, so their concentrations keep on decreasing.

Step 4: Teacher uses concept map to discuss the effect of light with the students. When light as a source of energy energizes the particles involved, the rates of some chemical reactions are being influenced. For example, in bright sunlight hydrogen and chlorine react explosively, in the day light, the reaction is moderate but in the absence of light it is almost negligible such reactions are known as photochemical reactions. Other examples of photochemical reactions include:

- (i) the conversion of silverhalides to grey metallic silver
- (ii) photosynthesis in plant
- (iii) the reaction between methane and chlorine
- (iv) the decomposition of hydrogen peroxides

In these reactions the reactant particles absorb light energy and react rapidly in a series of chain reaction.

Step 5: Teacher uses concept map to discuss the effect of change in temperature with the students. The rates of virtually all chemical reactions increase when the temperature is raised. This effect is noticed in both exothermic and endothermic reactions. Ababio (2011) opined that “the number of effective collision increases and the reaction proceeds at a faster rate when the temperature of a system is increased because, when the temperature is raised, energy in form of heat is supplied to the reactant particles, and the number of particles with energies equal to or greater than the activation energy increases; the average speed of all the reactant particles increases as a result of the greater kinetic energy, resulting into a higher frequency of collision” (p. 258).

As a result, the number of effective collision increases and the reaction proceeds at a faster rate.

Step 6: Teacher guides students by using concept map to explain effect of surface area of reactant. Increase in the area of contact of the reacting substance leads to increase in the rate of chemical reaction. The greater the surface area of reactant, the higher the reaction rate. The surface area of the solid can be increased when it breaks into smaller pieces. This will give room for increase in contact between the reacting particles. For instance, a marked difference is observed in the rate of reaction of powdered marble and marble chips with hydrochloric acid. The acid reacts more vigorously and faster with powdered marble than with the marble chips.

Students’ Activities:

- i. Students respond to teacher’s questions on collision theory.
- ii. Students listen attentively and click navigation words as the teacher explains nature of reactant, pressure, concentration, light, temperature and surface area as factors that affect rates of chemical reactions.

iii. Students participate in dissolving two types of sugar (granulated and cube) for better understanding of effect of surface area.

Evaluation (10mins): Explain how the following affect the rate of chemical reaction

- (i.) Temperature
- (ii.) Surface area of reactant

Conclusion (4mins): Teacher summarizes the whole lesson

Assignment (6mins): (i.) State two factors that could increase the rate of the reaction
(ii.) Explain why the factors stated in (i) would increase the reaction rate.

4TH AND 5TH PERIODS

Subject: Chemistry

Topic: Factors affecting the rates of chemical reactions

Sub-Topic: Catalyst

Average Age: 16 years

Duration: 80 minutes

Reference Book: (i) New School Chemistry by O.Y Ababio (ii.) Chemistry for Senior Secondary Schools 2 by STAN

Instructional Materials: Computer to display types of catalyst.

Behavioral Objectives: At the end of the lesson students should be able to

- (i) define catalyst
- (ii) state types of catalyst
- (iii) draw energy profiles for catalyzed reaction
- (iv) explain endothermic reaction
- (v) explain exothermic reaction
- (vi) explain $H^{\ddagger}$ notation
- (vii) state examples of catalyst of some common reactions
- (viii) state characteristics of a catalyst

Previous Knowledge: Students had been familiar with other factors that affect rates of chemical reactions.

Introduction (4mins): Teacher introduces the lesson by asking students questions on previous lesson.

Presentation (56mins)

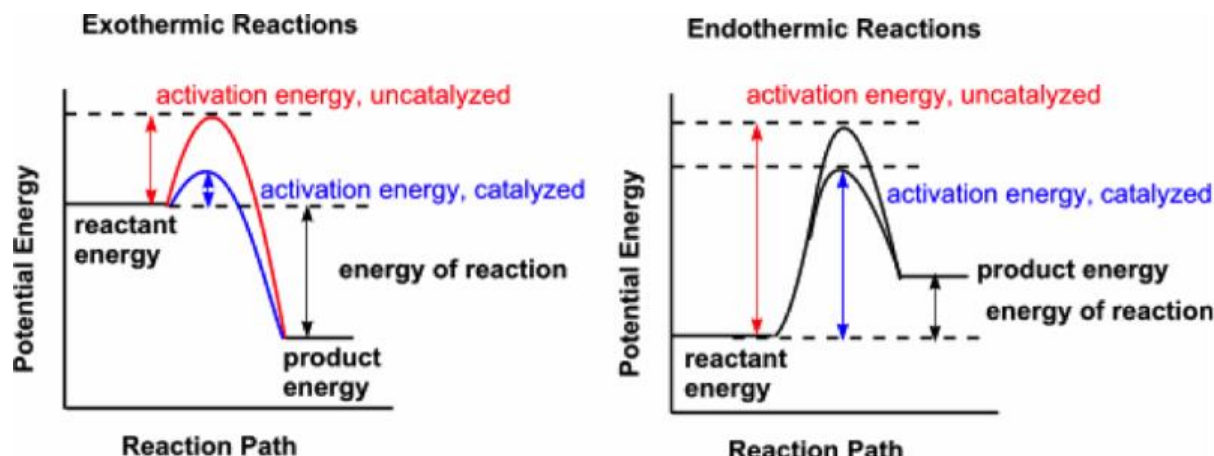
Teacher's Activities

Step 1: Teacher uses concept map to guide the students in discussing the meaning of catalyst.

A substance which alters the rate of a chemical reaction but does not change chemically at the end of the reaction is called a catalyst.

Step 2: Teacher uses concept map to discuss two types of catalyst with the students. A catalyst functions by providing another way for the reaction. If the other way has lower activation energy, the catalyst is said to be a positive catalyst, whereas a catalyst with higher activation energy is known as a negative catalyst. A positive catalyst lowers the energy barrier of a chemical reaction. Therefore, when there is a catalyst, it gives room for more reactant particles to react when they collide.

Step 3: Teacher uses concept map to explain energy profile of catalyzed reaction with the students.

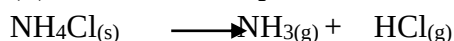


Step 4: Teacher uses concept map to explain endothermic reaction. The chemical reaction in which heat is absorbed from the surroundings is called endothermic reaction. Examples of endothermic reactions are:

(i) Thermal decomposition of Potassiumtrioxochlorate(v)



(ii) Thermal decomposition of ammonium chloride



Step 5: Teacher uses concept map to initiate discussion on exothermic reaction with the students.

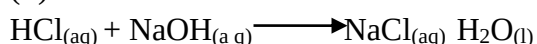
In the course of any chemical reaction, energy heat is either evolved to or absorbed in from the surroundings, depending on the heat content of reactants and the products. When heat is given off to the surroundings in a chemical reaction, the reaction is known as exothermic reaction.

Examples of exothermic reactions are:

(i) Reaction between calciumoxide and water



(ii) Reaction between an acid and a base



Step 6: Teacher uses concept map to discuss Enthalpy with the students.

The term enthalpy is simply the heat content of a chemical reaction and is represented by the letter H. The heat content of the reactant is represented by H_r while the heat content of the product is represented by H_p . The enthalpy change is the variation between the heat content of the product and reactant, and it can be represented by the symbol ΔH (delta = change in) i.e. $\Delta H = H_p - H_r$

ΔH is negative for an exothermic reaction while it is positive for endothermic reaction.

Step 7: Teacher uses concept map to state and discuss examples of some catalysts for some common reactions with the students.

Catalyst	Reaction
1. Manganese (iv) oxide (MnO ₂)	Thermal decomposition of potassium trioxochlorate (v) $2\text{KClO}_3 \longrightarrow 2\text{KCl}_{(\text{s})} + 3\text{O}_{2(\text{g})}$
2. Vanadium (v) oxide (V ₂ O ₅)	Synthesis of Sulphur(iv)oxide $2\text{SO}_{2(\text{aq})} + \text{O}_{2(\text{g})} \longrightarrow 2\text{SO}_{3(\text{g})}$
3. Reduced Iron Powder	Synthesis of Ammonia $\text{N}_{2(\text{g})} + 3\text{H}_{2(\text{g})} \longrightarrow 2\text{NH}_{3(\text{g})}$
4. Finely divided Nickel	Formation of Margarine from $\text{Vegetable oil}_{(\text{l})} + \text{H}_{2(\text{g})} \longrightarrow \text{Margarine}$

Step 8: Teacher uses concept map to discuss characteristics of a catalyst with the students as:

- a catalyst changes rate of a chemical reaction;
- a catalyst's chemical nature and mass persist at the end of a reaction;
- a catalyst is precise in action;
- a reaction cannot start by a catalyst but only effective in a reaction which has started;
- the types of products formed in a reaction are not affected by a catalyst;
- the equilibrium position of a reversible reaction is not affected by a catalyst; and
- a catalyst present in a very small amount will affect the rate of a reaction.

Students Activities

- i. Students respond to the teacher's questions on their previous knowledge
- ii. Students participate in defining catalyst
- iii. Students participate by clicking navigation word to view energy profiles for catalyzed reaction
- iv. Students listen attentively as the teacher explains endothermic, exothermic and ΔH notation.
- v. Students listen attentively as the teacher states examples of catalysts of some common reactions
- vi. Students listen attentively as the teacher describes characteristics of a catalyst.
- vii. Students ask questions for better understanding of the topic.

Evaluation (10mins): Teacher asks the following questions:

- (i) Define the term catalyst and state five characteristics of a catalyst.
- (ii) State a suitable catalyst for the production of Margarine.

Conclusion (10mins): Teacher summarizes the whole lesson.

LESSON NOTE FOR EXPERIMENTAL GROUP 2 (COMPUTER-BASED MIND MAPPING)

1ST PERIOD

Subject: Chemistry

Topic: Rates of chemical reactions

Class: SS2

Average Age: 16 years

Duration: 40 minutes

Reference Book: (i.) New School Chemistry by O.Y Ababio (ii.) Chemistry for Senior Secondary Schools 2 by STAN

Instructional materials: Picture of two runners.

Behavioral Objectives: At the end of the lesson students should be able to:

- (i) define rates of chemical reactions
- (ii) calculate the rate of a given reaction
- (iii) explain the rate curve
- (iv) explain the collision theory

Previous Knowledge: Students have been familiar with types of reactions such as Oxidation, Reduction, Decomposition, Displacement, Double decomposition etc.

Introduction (5mins): Teacher introduces the lesson by asking the students to list some reactions that they know. Teacher then asks them to explain catalytic reaction. Teacher then explains that all runners start at the same time but it takes them different times to run the course. This is because they all run at rates. The time taken for different chemical reactions to occur can vary a great deal.

Presentation

Teacher's Activities (27mins)

Step 1: Teacher uses mind map to guide discussion on the rate of chemical reaction with the students. The number of moles of reactant converted or product formed per unit time is the rate of chemical reaction.

For reaction $\text{Zn}_{(s)} + 2\text{HCl}_{(aq)} \longrightarrow \text{ZnCl}_{(s)} + \text{H}_{2(g)}$

Teacher then uses different pictures on the map to explain that the rate of reaction can be measured by:

- decrease in the mass of the reaction system
- volume of a gaseous product
- amount of precipitate formed
- time taken to arrive at an early seen stage
- changes in intensity of color
- changes in PH
- changes in total gas pressure

Step 2: Teacher uses mind map to guide students to calculate the rate of a chemical reaction.

Generally, Reaction rate = Change in concentration of reactant/product

Time taken for change

The unit is g/min, cm²/min

Example: What is the rate of reaction when 0.5g of calciumtrioxocarbonate (iv) was added to excess dilute hydrochloric acid, carbon(iv)oxide was evolved? The entire reaction took 5 minutes.

Solution:

Rate of reaction =
$$\frac{\text{Mass of reactant (CaCO}_3\text{)}}{\text{Time taken}}$$

= $\frac{0.5\text{g}}{5\text{min}}$

= 0.1g/min

Step 3: Teacher discusses the rate curve by using mind map with the students. The graph which shows the rate of reaction is known as rate curve. The curve passes through the origin because there is no loss in mass at the beginning of the reaction. The gradient of the curve measures how quickly the concentration is changing.

Gradient/slope = Adjacent

Opposite is the reaction rate if a straight line or tangent at a point, if it is a curve. If the gradient is greater the rate is faster and the rate is slower by the small gradient.

Step 4: Teacher discusses collision theory with the aid of picture of colliding cars on mind map with the students.

Ababio (2011) penned that “the collision theory assumes that there must be collision between reactant particles for a chemical reaction to occur and there are many such collisions, only a small fraction of them result in a reaction, this is called effective collision, therefore, for a reaction to occur the colliding reactant particles must possess a certain minimum amount of energy called **Activation energy**” (p.245). This is the energy barrier that must be overcome before bonds are stretched and sufficiently broken to enable the reaction take place. This reaction occurs if the energy of the colliding reactant particles is equal to or more than the activation energy. When this activation energy is acquired by the reactant particles they form a complex particle of high energy content. This high energy particle is known as activated complex.

Ababio (2011) further explained that “for a chemical reaction to occur, the minimum amount of energy possessed by the colliding reactant particles for a chemical reaction to occur is therefore, called activation energy and the collision theory can be used to explain how changes in temperature, concentration, nature of reactant and presence of the catalyst affect the rates of chemical reactions” (p. 253).

Student's Activities

- i. Students respond to teacher's questions on their previous knowledge.
- ii. Students participate in defining rates of chemical and mention different ways by which rate of a reaction can be measured.
- iii. Students participate in calculating rate of a chemical reaction
- iv. Students listen attentively as the teacher explains the rate curve
- v. Students listen carefully as the teacher describes collision theory.
- vi. Students ask questions for better understanding of the topic

Evaluation (3mins): Teacher asks the following questions

- (iv) What is meant by the rates of chemical reactions?
- (v) Explain the term collision theory.
- (vi) Explain the term activation energy.

Conclusion (2mins): Teacher summarizes the whole lesson.

Assignment (3mins): Use collision theory to explain physical state and its effects on reaction rates.

2ND AND 3RD PERIODS

Subject: Chemistry

Topic: Factors that affect the rate of a chemical reaction

Class: SS2

Average Age: 16 years

Duration: 80 minutes

Reference Book:(i) New School Chemistry by O.Y Ababio (ii.) Chemistry for Senior Secondary Schools 2 by STAN

Instructional material: Sugar (granulated and cube)

Behavioral Objectives: At the end of the lesson students should be able to:

- (vii) explain nature of reactants as factor that affects rate of a chemical reaction.
- (viii) explain effect of change in pressure as factor that affects rate of a chemical reaction.
- (ix) explain effect of change in concentration as factor that affects rate of a chemical reaction.
- (x) explain effect of light as factor that affects rate of a chemical reaction
- (xi) explain effect of change in temperature as factor that affects rate of a chemical reaction.
- (xii) explain effect of surface area as factor that affects rate of a chemical reaction.

Introduction (4mins): Teacher introduces the lesson by making reference to collision theory of the previous lesson, that it can be used to explain how nature of reactant, changes in temperature, concentration, pressure and catalyst affect the rate of chemical reaction.

Presentation (56 mins)

Teacher's Activities

Step 1: Teacher uses pictures of on mind map to discuss nature of reactant as a factor affecting the rates of chemical reaction with students. The rate of a chemical reaction of substances is a function of their chemical nature because they have different energy contents.

For instance, when a piece of iron is placed in dilute hydrochloric acid, there is a slow evolution of hydrogen gas, with a piece of zinc, hydrogen is evolved rapidly and with a piece of gold, there is no evidence of a reaction.

Step 2: Teacher uses picture of collided cars on mind map to explain effect of concentration of reactants. Reactant particles will collide more often if they are crowded in a small space i.e. frequency of collision is dependent upon concentration. The effective collisions of the reactant and the reaction rate increase or decrease with equivalent increase or decrease in concentration of reactants.

Step 3: Teacher uses picture of bicycle pump on mind map to discuss the effect of change of pressure for gasses. Pressure affects the concentration of gaseous reactants. For example, a mixture of hydrogen and chlorine gasses will react twice as fast if the partial pressure of hydrogen or chlorine is increased from 0.5 to 1.0atm. The concentration of solid and liquid is unaffected by changes in pressure. In a nutshell, reaction rate decreases with time because as reaction proceeds, the reactant are being used up, so their concentrations continue decreasing.

Step 4: Teacher uses picture of sun light on mind map to discuss the effect of light with the students. The rates of some chemical reactions can be influenced by light as a source of energy by increasing the energy of particles involved. For example, in bright sunlight hydrogen and chlorine react explosively, in the day light, the reaction is moderate but in the absence of light it is almost negligible such reactions are known as photochemical reactions. Other examples of photochemical reactions include:

- (v) the conversion of silver halides to grey metallic silver
- (vi) photosynthesis in plant
- (vii) the reaction between methane and chlorine
- (viii) the decomposition of hydrogen peroxides

In these reactions the reactant particles absorb light energy and react rapidly in a series of chain reaction.

Step 5: Teacher uses pictures such as thermometer and jet on mind map to discuss the effect of change in temperature with the students. The rates of virtually all chemical reactions increase when the temperature is raised. This effect is observed in both exothermic and endothermic reactions. Increasing the temperature of a system can lead to an increase in reaction rate in two ways. When there is increase in the number of effective collision, the reaction continues at a faster rate and energy in form of heat is supplied to the particles of reactant when the temperature is increased. The number of particles with energies equal to or greater than the activation energy increases; the average speed of all the reactant particles increases as a result of the greater kinetic energy, resulting into a higher frequency of collision.

As a result, the number of effective collision increases and the reaction proceeds at a faster rate.

Step 6: Teacher uses pictures of powdered and marble chip on mind map to discuss the effect of surface area of reactant with the students. Increase in the area of contact of the reacting substance leads to increase in the rate of chemical reaction. The greater the surface area of reactant, the higher the reaction rate. The surface area of the solid can be increased when it breaks into smaller pieces. This will give room for increase in contact between the reacting particles. For instance, a marked difference is observed in the rate of reaction of powdered marble and marble chips with hydrochloric acid. The acid reacts more vigorously and faster with powdered marble than with the marble chips.

Students' Activities:

- i. Students respond to teacher's questions on collision theory.
- ii. Students listen attentively as the teacher explains nature of reactant, pressure, concentration, light, temperature and surface area as factors that affect rates of chemical reactions.

iii. Students participate in dissolving two types of sugar (granulated and cube) for better understanding of effect of surface area.

Evaluation (10mins): Explain how the following affect the rate of chemical reaction

- (i) Temperature
- (ii) Surface area of reactant

Conclusion (4mins): Teacher summarizes the whole lesson

Assignment (6mins): (i.) Mention two factors that could lead to increase in the rate of the reaction (ii.) Explain why the factors earlier mentioned would increase the reaction rate.

4TH AND 5TH PERIODS

Subject: Chemistry

Topic: Factors affecting the rate of chemical reaction

Sub-Topic: Catalyst

Average Age: 16 years

Duration: 80 minutes

Reference Book: (i) New School Chemistry by O.Y Ababio (ii.) Chemistry for Senior Secondary Schools 2 by STAN

Instructional Materials: Computer showing different types of catalyst

Behavioral Objectives: At the end of the lesson students should be able to

- (ix) define catalyst
- (x) state types of catalyst
- (xi) draw energy profiles for catalyzed reaction
- (xii) explain endothermic reaction
- (xiii) explain exothermic reaction
- (xiv) explain ΔH notation
- (xv) state examples of catalyst of some common reactions
- (xvi) state characteristics of a catalyst

Previous Knowledge: Students had been familiar with other factors that affect rate of chemical reactions.

Introduction (4mins): Teacher introduces the lesson by asking students questions on previous lesson.

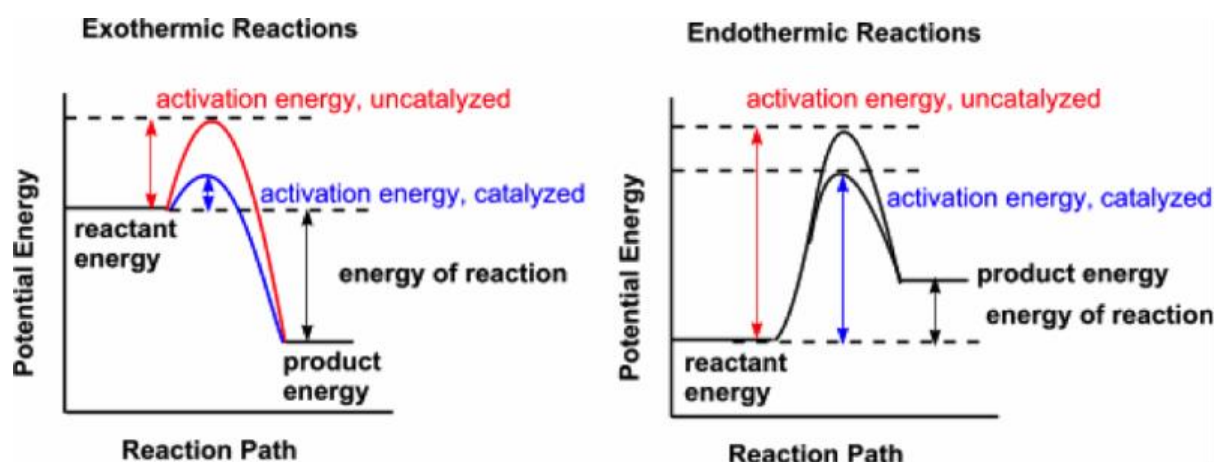
Presentation (56mins)

Teacher's Activities

Step 1: Teacher uses mind map to guide students in explaining the meaning of catalyst. Ababio (2011) defined catalyst as “a substance which alters the rate of a chemical reaction but does not change chemically at the end of the reaction” (p. 260).

Step 2: Teacher uses mind map to guide students to identify two types of catalyst. A catalyst functions by giving alternative way for the reaction. If the other way has lower activation energy, the catalyst is said to be a positive catalyst, whereas a catalyst with higher activation energy is known as a negative catalyst. A positive catalyst lowers the energy barrier of a chemical reaction. Therefore, when there is a catalyst, it gives room for more reactant particles to react when they collide.

Step 3: Teacher uses mind map to explain energy profile of catalyzed reaction.

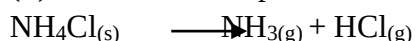


Step 4: Teacher uses mind map to guide class discussion on endothermic reaction. The chemical reaction in which heat is absorbed from the surroundings is called endothermic reaction. Examples of endothermic reactions are:

(i) Thermal decomposition of Potassium trioxochlorate(v)



(ii) Thermal decomposition of ammonium chloride



Step 5: Teacher uses mind map to guide class discussion on exothermic reaction.

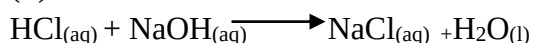
In the course of any chemical reaction, energy heat is either evolved to or absorbed in from the surroundings, depending on the heat content of reactants and the products. When heat is given off to the surroundings in a chemical reaction, the reaction is known as exothermic reaction.

Examples of exothermic reaction are:

(i) Reaction between calciumoxide and water



(ii) Reaction between an acid and a base



Step 6: Teacher uses mind map to discuss ΔH notation with students.

The term enthalpy is simply the heat content of a chemical reaction and is represented by the letter H. The heat content of the reactant is represented by H_r while the heat content of the product is represented by H_p . The enthalpy change is the variation between the heat content of the product and reactant, and it can be represented by the symbol $(\Delta) = \text{change in}$ i.e $\Delta H = H_p - H_r$

ΔH is negative for an exothermic reaction while it is positive for endothermic reaction.

Step 7: Teacher uses mind map to guide students to identify examples of some catalysts for some common reactions.

Catalyst	Reaction
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1. Manganese (iv) oxide (MnO ₂)	Thermal decomposition of potassium trioxochlorate (v) $2\text{KClO}_3 \longrightarrow 2\text{KCl}_{(s)} + 3\text{O}_{2(g)}$
2. Vanadium (v) oxide (V ₂ O ₅)	Synthesis of Sulphur(iv)oxide $2\text{SO}_{2(aq)} + \text{O}_{2(g)} \longrightarrow 2\text{SO}_{3(g)}$
3. Reduced Iron Powder	Synthesis of Ammonia $\text{N}_{2(g)} + 3\text{H}_{2(g)} \longrightarrow 2\text{NH}_{3(g)}$
4. Finely divided Nickel	Formation of Margarine from $\text{Vegetable oil}_{(l)} + \text{H}_{2(g)} \longrightarrow \text{Margarine}$

Step8: Teacher uses mind map to guide students to identify characteristics of a catalyst as:

- a catalyst changes rate of a chemical reaction;
- a catalyst's chemical nature and mass persist at the end of a reaction;
- a catalyst is precise in action;
- a reaction cannot start by a catalyst but only effective in a reaction which has started;
- the types of products formed in a reaction are not affected by a catalyst;
- the equilibrium position of a reversible reaction is not affected by a catalyst; and
- a catalyst present in a very small amount will affect the rate of a reaction.

Students Activities

- i. Students respond to the teacher's questions on their previous knowledge
- ii. Students participate in defining catalyst
- iii. Students participate by clicking navigation words to view energy profiles for catalyzed reaction
- iv. Students listen attentively as the teacher explains endothermic, exothermic and ΔH notation.
- v. Students listen attentively as the teacher states examples of catalysts of some common reactions
- vi. Students listen attentively as the teacher describes characteristics of a catalyst.
- vii. Students ask questions for better understanding of the topic

Evaluation (10mins): Teacher asks the following questions:

- (i) Define the term catalyst and state five characteristics of a catalyst.
- (ii) State a suitable catalyst for production of margarine

Conclusion (5mins): Teacher summarizes the whole lesson

APPENDIX III

LESSON NOTES FOR CONTROL GROUP

1STPERIOD

Subject: Chemistry

Topic: Rate of chemical reactions

Class: SS2

Average Age: 16 years

Duration: 40 minutes

Reference Book: (i.) New School chemistry by O.Y Ababio (ii.) Chemistry for Senior Secondary Schools 2 by STAN

Instructional materials: Textbook and picture of two runners.

Behavioral Objectives: At the end of the lesson students should be able to:

- (i) define rates of chemical reactions
- (ii) calculate the rate of a given reaction
- (iii) explain the rate curve
- (iv) explain the collision theory

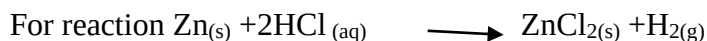
Previous Knowledge: Students have been familiar with types of reactions such as Oxidation, Reduction, Decomposition, Displacement, Double decomposition etc.

Introduction (5mins): Teacher introduces the lesson by asking the students to state some reactions that they know. Teacher then asks them to explain catalytic reaction. Teacher explains that all runners start at the same time but it takes them different times to run the course. This is because they all run at different rates.

Presentation

Teacher's Activities (27mins)

Step 1: Teacher explains the rate of chemical reaction as the number of moles of reactant converted or product formed per unit time.



Teacher lists ways by which rate of reaction can be measured. Rate of reaction can be measured by measuring the

- decrease in the mass of the reaction system
- volume of a gaseous product
- amount of precipitate formed
- time taken to arrive at an early seen stage
- changes in intensity of color
- changes in PH
- changes in total gas pressure

Step 2: Teacher explains calculation on rate of a chemical reaction.

Generally, Reaction rate = $\frac{\text{Change in concentration of reactant/product}}{\text{Time taken for change}}$

The unit is g/min, cm²/min

Example: What is the rate of reaction when 0.5g of calciumtrioxocarbonate(iv) was added to excess dilute hydrochloric acid, carbon(iv)oxide was evolved? The entire reaction took 5 minutes.

Solution:

Rate of reaction = $\frac{\text{Mass of reactant (CaCO}_3\text{)}}{\text{Time taken}}$

$$= \frac{0.5\text{g}}{5\text{min}}$$

$$= 0.1\text{g/min}$$

Step 3: Teacher explains the rate curve. The graph which shows the rate of reaction is known as rate curve. The curve passes through the origin because there is no loss in mass at the beginning of the reaction. The gradient of the curve measures how quickly the concentration is changing.

Gradient/slope = $\frac{\text{Adjacent}}{\text{Opposite}}$ is the reaction rate if a straight line or tangent at a

Point, if it is a curve. If the gradient is greater the rate is faster and the rate is slower by the small gradient.

Step 4: Teacher explains collision theory.

Ababio (2011) penned that “the collision theory assumes that there must be collision between reactant particles for a chemical reaction to occur and there are many such collisions, only a small fraction of them result in a reaction, this is called effective collision, therefore, for a reaction to occur the colliding reactant particles must possess a certain minimum amount of energy called **Activation energy**” (p.245). This is the energy barrier that must be overcome before bonds are stretched and sufficiently broken to enable the reaction take place. This reaction occurs if the energy of the colliding reactant particles is equal to or more than the activation energy. When this activation energy is acquired by the reactant particles they form a complex particle of high energy content. This high energy particle is known as activated complex. The collision theory formed basis for explanation on how changes in temperature, concentration, nature of reactant and presence of the catalyst affect the rates of chemical reactions.

Student’s Activities

- i. Students respond to teacher’s questions on their previous knowledge.
- ii. Students participate in defining rates of chemical and mention different ways by which rate of a reaction can be measured.
- iii. Students participate in calculating rate of a chemical reaction
- iv. Students listen attentively as the teacher explains the rate curve
- v. Students listen carefully as the teacher describes collision theory.
- vi. Students ask questions for better understanding of the topic

Evaluation (3mins): Teacher asks the following questions

- (vii) What is meant by the rates of chemical reactions?
- (viii) Explain the term collision theory.
- (ix) Explain the term activation energy.

Conclusion (2mins): Teacher summarizes the whole lesson.

Assignment (3mins): Use collision theory to explain physical state and its effects on reaction rates.

2ND AND 3RD PERIODS

Subject: Chemistry

Topic: Factors that affect the rate of a chemical reaction

Class: SS2

Average Age: 16 years

Duration: 80 minutes

Reference Book: (i) New School Chemistry by O.Y Ababio (ii.) Chemistry for Senior Secondary Schools 2 by STAN

Instructional material: Text book and sugar (granulated and cube)

Behavioral Objectives: At the end of the lesson students should be able to:

- (xiii) explain nature of reactants as factor that affects rate of a chemical reaction.
- (xiv) explain effect of change in pressure as factor that affects rate of a chemical reaction.
- (xv) explain effect of change in concentration as factor that affects rate of a chemical reaction.
- (xvi) explain effect of light as factor that affects rate of a chemical reaction
- (xvii) explain effect of change in temperature as factor that affects rate of a chemical reaction.
- (xviii) explain effect of surface area as factor that affects rate of a chemical reaction.

Introduction (4mins): Teacher introduces the lesson by making reference to collision theory of the previous lesson, that it can be used to explain how nature of reactant, changes in temperature, concentration, pressure and catalyst affect the rate of chemical reaction.

Presentation (56 mins)

Teacher's Activities

Step 1: Teacher explains nature of reactant as a factor affecting the rate of chemical reaction. The rate of a chemical reaction of substances is a function of their chemical nature because they have different energy contents. For instance, when a piece of iron is placed in dilute hydrochloric acid, there is a slow evolution of hydrogen gas, with a piece of zinc, hydrogen is evolved rapidly and with a piece of gold, there is no evidence of a reaction.

Step 2: Teacher explains effect of concentration of reactants. Reactant particles will collide more often if they are crowded in a small space i.e. frequency of collision is dependent upon concentration. The effective collisions of the reactant and the reaction rate increase or decrease with equivalent increase or decrease in concentration of reactants.

Step 3: Teacher explains effect of change of pressure for gasses. Pressure affects the concentration of gaseous reactants. For example, a mixture of hydrogen and chlorine gasses will react twice as fast if the partial pressure of hydrogen or chlorine is increased from 0.5 to 1.0atm. The concentration of solid and liquid is unaffected by changes in pressure. In a nutshell, reaction rate decreases with time because as reaction proceeds, the reactant are being used up, so their concentrations continue decreasing.

Step 4: Teacher explains effect of light. Light is a source of energy and can influence the rates of some chemical reactions by energizing particles involved. For example, in bright sunlight hydrogen and chlorine react explosively, in the day light, the reaction is moderate but in the absence of light it is almost negligible such reactions are known as photochemical reactions. Other examples of photochemical reactions include:

- (ix) the conversion of silverhalides to grey metallic silver
- (x) photosynthesis in plant
- (xi) the reaction between methane and chlorine

(xii) the decomposition of hydrogen peroxides

In these reactions the reactant particles absorb light energy and react rapidly in a series of chain reaction.

Step 5: Teacher explains effect of change in temperature. The rates of virtually all chemical reactions increase when the temperature is raised. This effect is observed in both exothermic and endothermic reactions. Increasing the temperature of a system can lead to an increase in reaction rate in two ways. When there is increase in the number of effective collision, the reaction continues at a faster rate and energy in form of heat is supplied to the particles of reactant when the temperature is increased. The number of particles with energies equal to or greater than the activation energy increases; the average speed of all the reactant particles increases as a result of the greater kinetic energy, resulting into a higher frequency of collision. As a result, the number of effective collision increases and the reaction proceeds at a faster rate.

Step 6: Teacher explains effect of surface area of reactant. Increase in the area of contact of the reacting substance leads to increase in the rate of chemical reaction. The greater the surface area of reactant, the higher the reaction rate. The surface area of the solid can be increased when it breaks into smaller pieces. This will give room for increase in contact between the reacting particles. For instance, a marked difference is observed in the rate of reaction of powdered marble and marble chips with hydrochloric acid. The acid reacts more vigorously and faster with powdered marble than with the marble chips.

Students' Activities:

- i. Students respond to teacher's questions on collision theory.
- ii. Students listen attentively as the teacher explains nature of reactant, pressure, concentration, light, temperature and surface area as factors that affect rates of chemical reactions.
- iii. Students participate in dissolving two types of sugar (granulated and cube) for better understanding of effect of surface area.

Evaluation (10mins): Explain how the following affect the rate of chemical reaction

(iii) Temperature

(iv) Surface area of reactant

Conclusion (4mins): Teacher summarizes the whole lesson

Assignment (6mins): (i.) Mention two factors that could lead to increase in the rate of the reaction (ii.) Explain why the factors earlier mentioned would increase the reaction rate.

4TH AND 5TH PERIODS

Subject: Chemistry

Topic: Factors affecting the rate of chemical reactions

Sub-Topic: Catalyst

Average Age: 16 years

Duration: 80 minutes

Reference Book: (i) New School Chemistry by O.Y Ababio (ii.) Chemistry for Senior Secondary Schools 2 by STAN

Instructional Materials: Chart showing types of catalyst.

Behavioral Objectives: At the end of the lesson students should be able to

- (xvii) define catalyst
- (xviii) state types of catalyst
- (xix) draw energy profiles for catalyzed reaction
- (xx) explain endothermic reaction
- (xxi) explain exothermic reaction
- (xxii) explain ΔH notation
- (xxiii) state examples of catalyst of some common reactions
- (xxiv) state characteristics of a catalyst

Previous Knowledge: Students had been familiar with other factors that affect rates of chemical reactions.

Introduction (4mins): Teacher introduces the lesson by asking students questions on previous lesson.

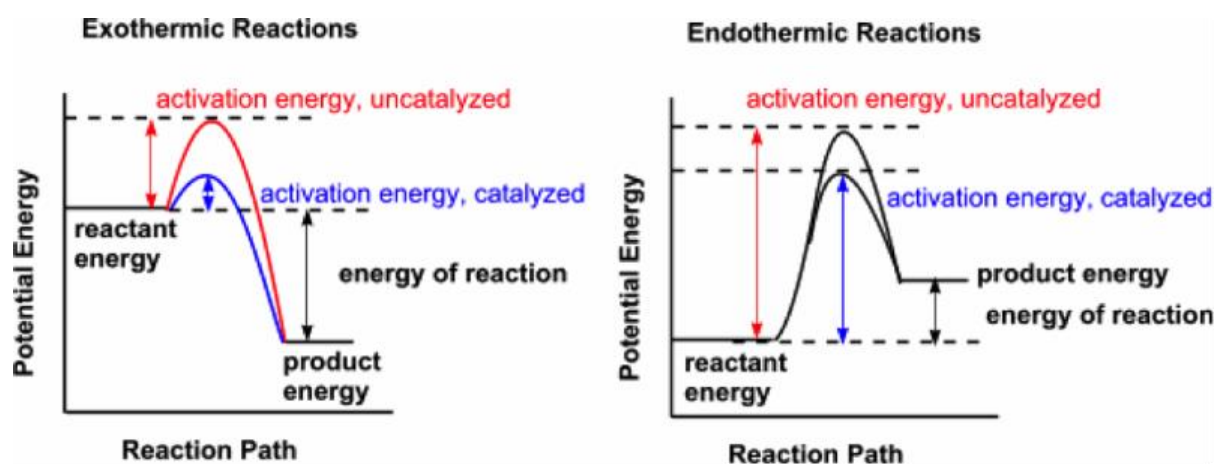
Presentation (56mins)

Teacher's Activities

Step 1: Teacher explains meaning of catalyst. Ababio (2011) defined catalyst as “a substance which alters the rate of a chemical reaction but does not change chemically at the end of the reaction” (p. 260).

Step 2: Teacher explains two types of catalyst. A catalyst functions by giving alternative way for the reaction. If the other way has lower activation energy, the catalyst is said to be a positive catalyst, whereas a catalyst with higher activation energy is known as a negative catalyst. A positive catalyst lowers the energy barrier of a chemical reaction. Therefore, when there is a catalyst, it gives room for more reactant particles to react when they collide.

Step 3: Teacher explains energy profile of catalyzed reaction

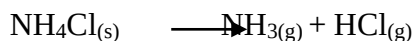


Step 4: Teacher explains endothermic reaction. The chemical reaction in which heat is absorbed from the surroundings is called endothermic reaction. Examples of endothermic reactions are:

(i) Thermal decomposition of Potassium trioxochlorate(v)



(ii) Thermal decomposition of ammonium chloride

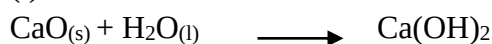


Step 5: Teacher explains exothermic reaction.

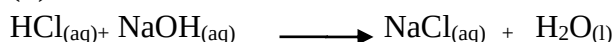
In the course of any chemical reaction, energy heat is either evolved to or absorbed in from the surroundings, depending on the heat content of reactants and the products. When heat is given off to the surroundings in a chemical reaction, the reaction is known as exothermic reaction.

Examples of exothermic reaction are:

(i) Reaction between calcium oxide and water



(ii) Reaction between an acid and a base



Step 6: Teacher explains Enthalpy

The term enthalpy is simply the heat content of a chemical reaction and is represented by the letter H. The heat content of the reactant is represented by H_r while the heat content of the product is represented by H_p . The enthalpy change is the variation between the heat content of the product and reactant, and it can be represented by the symbol (Δ) = change in) i.e. $\Delta H = H_p - H_r$

ΔH is negative for an exothermic reaction while it is positive for endothermic reaction. Δ

Step 7: Teacher states examples of some catalysts for some common reactions.

Catalyst

Reaction

1. Manganese (iv) oxide (MnO_2)

Thermal decomposition of potassium trioxochlorate (v) $2\text{KClO}_3 \longrightarrow 2\text{KCl}_{(s)} + 3\text{O}_{2(g)}$

2. Vanadium (v) oxide (V_2O_5)

Synthesis of Sulphur(iv) oxide
 $2\text{SO}_2(aq) + \text{O}_{2(g)} \longrightarrow 2\text{SO}_3(g)$

3. Reduced Iron Powder

Synthesis of Ammonia
 $\text{N}_{2(g)} + 3\text{H}_{2(g)} \longrightarrow 2\text{NH}_{3(g)}$

4. Finely divided Nickel

Formation of Margarine from

Vegetable oil $(l) + \text{H}_{2(g)} \longrightarrow$ Margarine

Step 8: Teacher states characteristics of a catalyst.

- a catalyst changes rate of a chemical reaction;
- a catalyst's chemical nature and mass persist at the end of a reaction;
- a catalyst is precise in action;
- a reaction cannot start by a catalyst but only effective in a reaction which has started;
- the types of products formed in a reaction are not affected by a catalyst;
- the equilibrium position of a reversible reaction is not affected by a catalyst; and
- a catalyst present in a very small amount will affect the rate of a reaction.

Students Activities

- i. Students respond to the teacher's questions on their previous knowledge
- ii. Students participate in defining catalyst
- iii. Students listen as teacher explain energy profiles for catalyzed reaction
- iv. Students listen attentively as the teacher explains endothermic, exothermic and ΔH notation.
- v. Students listen attentively as the teacher states examples of catalysts of some common reactions
- vi. Students listen attentively as the teacher describes characteristics of a catalyst.
- vii. Students ask questions for better understanding of the topic

Evaluation (10mins): Teacher asks the following questions:

- (i) Define the term catalyst and state five characteristics of a catalyst.
- (ii) State a suitable catalyst for the production of Margarine.

Conclusion (10mins): Teacher summarizes the whole lesson

APPENDIX IV

CHEMISTRY INTEREST SCALE (CIS)

Name of school _____

Class _____

Sex: Male ☐ Female ☐ (Tick one)

This inventory is designed to help you indicate the level of your opinion on rates of chemical reactions as one of the senior secondary school chemistry units. Please indicate freely your extent of agreement or disagreement with the following statements by ticking the right response in the appropriate box. Please note that SA stands for strongly agree, A stands for agree, D stands for disagree, and SD for strongly disagree.

S/N	ITEMS	SA	A	SD	D
1	I find rates of reactions in chemistry lessons very fascinating.				
2	I do not feel bored during chemistry lessons.				
3	I will like to offer any optional course relating to Rates of chemical reactions in higher institution.				
4	Energy profile diagrams are easy to draw.				
5	I like going to class whenever we have concept of collision theory as a topic.				
6	I will not study further any course involving calculations on rates of chemical reactions.				
7	I can now solve chemistry questions in textbooks.				
8	My best area in the units of chemistry is rates of chemical reactions				
9	I can now be confident in asking questions in chemistry.				
10	I feel happy teaching my younger ones about rate of				

	chemical reactions.				
11	I don't like questions on factors affecting rates of chemical reactions in chemistry				
12	Knowledge of catalysts in chemistry is very interesting.				
13	I can now relate chemistry topics to real life				
14	Project and assignment on rates of chemical reaction in chemistry do not interest me at all.				
15	Without knowledge of rate of chemical reactions life must continue				
16	Rates of chemical reactions concept is not relevant to learning chemistry				
17	I can now offer chemistry as a major course in higher institution				
18	I feel happy copying my chemistry note when it is on rates of chemical reactions				
19	I can now relate very well with my chemistry teacher				
20	Knowledge of rates of chemical reaction cannot contribute to success				

APPENDIX V

CHEMISTRY ACHIEVEMENT TEST ON RATE OF REACTIONS (CATOROR) PRE-TEST AND POST-TEST SECTION A

Demographic data of student

Name of school _____

Class _____

Gender _____ Age _____

SECTION B

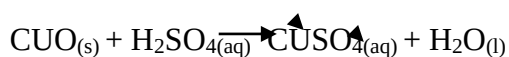
Duration: 30 minutes

Instruction: Read carefully and choose the answer you consider most appropriate in the option lettered A-D

- The determination of heat of combustion is carried out with
 - thermometer
 - a bomb calorimeter

- C. an evaporating dish
- D. a boiling tube
2. The minimum amount of energy required for effective collision between reacting particles is known as
- activation energy
 - bond energy
 - kinetic energy
 - potential energy
3. The rate of chemical reactions of solids are not affected by
- catalyst
 - pressure
 - particle size
 - temperature
4. Which of the following would increase the rate of reaction of chips of a metal M as shown in the equation below?
- $$\text{M}_{(\text{s})} + 2\text{HCl}_{(\text{aq})} \longrightarrow \text{MCl}_{2(\text{aq})} + \text{H}_{2(\text{g})}$$
- Diluting the hydrochloric acid
 - Adding some distilled water
 - Decreasing the temperature
 - Grinding the metal into powder
5. Which of the following statements about enthalpy of neutralization is correct? It
- is constant for a strong acid and a strong base
 - cannot be determined using calorimeter
 - has positive value
 - is higher for a strong acid and a weak base
6. When $\text{NH}_4\text{Cl}_{(\text{s})}$ was dissolved in water the container was cold to touch. This implies that
- the process is endothermic
 - the process is exothermic
 - NH_4Cl is highly soluble in water
 - NH_4Cl forms a saturated solution
7. Which of the following conditions would lead to an increase in the rate of a reaction?
- Increase in temperature and decrease in the surface area of reactant
 - Increase in both temperature and concentration of reactant
 - When the temperature is decreased and the concentration is increased
 - When the temperature is decreased and the surface area of reactants is increased

8. From the reaction represented by the following equation:



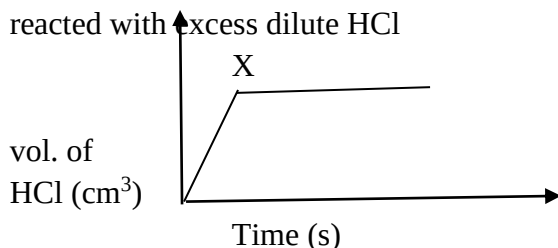
The rate of the reaction will not be affected by -----

- A. the particle size of $\text{CuO}_{(s)}$
 - B. concentration of $\text{H}_2\text{SO}_{4(aq)}$
 - C. temperature of the reactants
 - D. pressure of the system
9. ----- lowers the activation energy of a chemical reaction?
- A. Petrol
 - B. Oxidizing agent
 - C. Catalyst
 - D. Water
10. Which of the following processes is an endothermic reaction?
- A. Dissolving NH_4Cl crystals in water
 - B. Addition of concentrated H_2SO_4 to water
 - C. Dissolving NaOH pellets in water
 - D. Passing SO_3 gas into water
11. The type of energy changes that accompany the mixing of a strong acid to strong base is
- A. electrical
 - B. heat
 - C. light
 - D. sound
12. When heat is absorbed during a chemical reaction, the reaction is said to be
- A. adiabatic
 - B. endothermic
 - C. exothermic
 - D. isothermal
13. When reaction is endothermic
- A. enthalpy change is negative, i.e. ΔH is negative
 - B. heat content of product is less than heat content of reactant

C. heat content of reactant is less than heat content of product

D. the reaction is non-spontaneous

14. The following diagram illustrates the rate curve that was obtained when Mg reacted with excess dilute HCl



The diagram became horizontal at X because

- A. the reaction was slowed down
- B. all the dilute HCl has reacted
- C. all the Mg has reacted
- D. hydrogen gas is produced at a steady rate
15. ----- is the minimum amount of energy required for effective collisions between particles of reactants.
- A. Activation energy
- B. Kinetic energy
- C. Mechanical energy
- D. potential energy
16. The reaction;
 $\text{H}_3\text{O}^+_{(\text{aq})} + \text{OH}^-_{(\text{aq})} \rightarrow \text{H}_2\text{O}_{(\text{l})}$ represents -----
- A. polymerization
- B. saponification
- C. neutralization
- D. hydrolysis
17. Which of the following factors will affect the rate of the reaction represented by the following equations?
 $2\text{HCl}_{(\text{aq})} + \text{CaCO}_{3(\text{s})} \rightarrow \text{CaCl}_{2(\text{aq})} + \text{H}_2\text{O}_{(\text{l})} + \text{CO}_{2(\text{g})}$
- A. pressure and nature of reactant
- B. nature of reactants, concentration and temperature
- C. Pressure, concentration and nature of reactants
- D. Pressure, concentration, nature of reactants and temperature

Which of the following properties is/are not exhibited by catalysts?

- I. Altering the rate of a chemical reaction
- II. Same mass and composition at the end of reaction

- III. Causing a change in the equilibrium position of a reversible reaction
- IV. Starting off a reaction which will normally not occur
- A. IV only
- B. I and II only
- C. III and IV only
- D. I, II and III only
18. Which of the following does not affect the rate of a chemical reaction?
- A. The reactants' concentration
- B. Presence of a catalyst
- C. The reacting particles' size
- D. The enthalpy change for the reaction
19. Given that for the reaction $\text{KOH}_{(aq)} + \text{HCl}_{(aq)} \longrightarrow \text{KCl}_{(aq)} + \text{H}_2\text{O}_{(l)}$
- $$\Delta H = 54 \text{ KJmol}^{-1}$$
- What is the quantity of heat evolved in the reaction,
- $$2\text{NaOH}_{(aq)} + \text{H}_2\text{SO}_{4(aq)} \longrightarrow \text{Na}_2\text{SO}_{4(aq)} + 2\text{H}_2\text{O}_{(l)}?$$
- A. -180KJ
- B. -54KJ
- C. -27KJ
- D. +27KJ
20. Which of the following statements is/are correct of ΔH , the enthalpy of reaction, ΔH is?
- I. The heat change accompanying a chemical reaction
- II. Negative for exothermic reaction
- III. Positive for endothermic reactions
- IV. Greater than ΔH for reversible reactions
- A. IV only
- B. I and III
- C. III and IV
- D. I, II and III
21. The heat accompanying the reaction represented by the equation $\text{H}_2\text{O}_{(l)} \longrightarrow \text{H}_2\text{O}_{(g)}$ is described as the heat of
- A. solution
- B. neutralization
- C. vaporization
- D. Combustion
22. A Catalyst increases the rate of a chemical reaction by -----

- A. increasing the pathway of the reaction
 - B. increasing the reactants' surface area
 - C. increasing the pressure of the system
 - D. decreasing the activation energy of the reaction
23. Endothermic reaction is when
- I. Heat is absorbed from surrounding
 - II. The heat content of the reactant is lower than that of the product
 - III. Change in heat content is positive
 - IV. When the system is at higher temperature than the surrounding at a lower temperature than the system
- A. I only
 - B. I and II only
 - C. I, II and III only
 - D. I, II, III and IV
24. $\text{CH}_4(\text{g}) + 2\text{O}_2(\text{g}) \rightarrow 2\text{H}_2\text{O}(\text{l}) + \text{CO}_2(\text{g}) \quad \Delta H = -890 \text{ kJ mol}^{-1}$. ΔH in the reaction represented by the equation above is the enthalpy of
- A. formation
 - B. combustion
 - C. solution
 - D. neutralization
25. The rate of a reaction is proportional to the number of effective collisions occurring per second between the reactants". The statement is in connection with
- A. Faraday's law of electrolysis
 - B. collision theory
 - C. Dalton atomic theory
 - D. Modern atomic theory
26. A reaction is exothermic, when:
- A. The vessel of the reaction becomes hotter as the reaction continues
 - B. ΔH for the reaction is positive
 - C. There is increase in the rate of the reaction with time
 - D. The reaction has high activation energy
27. The energy of motion that the reacting species possess in a chemical is known as -----
- A. potential energy
 - B. free energy
 - C. Electrical energy

- D. kinetic energy
28. In the reaction between Zinc granules and hydrochloric acid, the rate of production of hydrogen gas can be increased by
- A. cooling the reaction mixture
 - B. using powdered zinc instead of granules
 - C. carrying out the reaction in closed vessel
 - D. carrying out the reaction at a higher pressure
29. Consider the reaction represented by the following equation;
- $\text{H}_{2(g)} + \text{I}_{2(g)} \longrightarrow 2\text{HI}$. The number of effective collision of molecules of the reactant decreases as
- A. the temperature is raised
 - B. the pressure is increased
 - C. the volume of the system is increased
 - D. a catalyst is introduced into the system

APPENDIX VI

ANSWERS TO CHEMISTRY ACHIEVEMENT TEST ON RATE OF REACTIONS (CATOROR)

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

- 20. C
- 21. C
- 22. C
- 23. D
- 24. D
- 25. B
- 26. D
- 27. A
- 28. D
- 29. B
- 30. C

APPENDIX VII

Course Content	Knowledge	Comprehension	Application	Total
Rates of chemical reaction	2	1	1	4
Rate curve	1		1	2
Collision Theory	2	1	1	4
Energy	1	1	1	3
Factors that affect rate of Chemical Reactions	2	2	2	6

Catalyst	1	2	1	4
Exothermic Reactions	1	1	1	3
Endothermic Reactions	2	1	1	4
Total	12	9	9	30

**TABLE OF SPECIFICATION FOR CHEMISTRY ACHIEVEMENT TEST ON
RATE OF REACTION**

APPENDIX VIII

The Visual, Auditory and Kinaesthetic Learning Style Test (VLST)

NAME:

SCHOOL:

GENDER: Male () Female () tick as appropriate

Circle or tick the answer that most represents how you generally behave.

1. During practical chemistry, I am most comfortable:
 - a) watching what the teacher is doing
 - b) talking through with the teacher exactly what I'm supposed to do
 - c) giving it a try myself and work it out as I go
2. It is convenient for me to recollect:
 - a) faces
 - b) names
 - c) what I have done with my hands
3. If I was purchasing a new phone, I would:
 - a) read reviews in newspapers and social media
 - b) I will have a discussion with my classmate about what I need
 - c) Like to test different types

4. During revision in preparation for chemistry exam, I generally:

- a) write lots of revision notes and diagrams
- b) discuss notes with others in the class
- c) Creating formula in imagination

5. If I am teaching my younger ones a new topic, I tend to:

- a) write instructions down for them
- b) give them a verbal explanation
- c) demonstrate first and then let them have a go

6. When I'm less busy, I enjoy:

- a) going to museums and galleries
- b) listening to music and talking to my friends
- c) playing sport

7. When I go shopping for wears, I tend to:

- a) imagine what they would look like on
- b) discuss them with the seller
- c) try them on and test them out

8. When I need to travel to a new place I usually:

- a) look at a map
- b) ask for spoken directions
- c) follow my nose and maybe use a compass

9. I like to say:

- a) watch how I do it
- b) listen to my explanation
- c) you have a go

10. If I am to prepare a new dish, I swing to:

- a) visualize what the food will look like
- b) talk through the alternatives in my head or with my friend
- c) envisage what the food will taste like

11. I make choice of bags because I like:

- a) their colours and outlook

- b) the explanation the sellers give me
- c) what it feels like when touching

12. I like:

- a) gazing at something
- b) being talked to
- c) doing something

13. I like having relationship with other people because of:

- a) how they look
- b) what they say to me
- c) how they make me feel

14. Anytime I prepare a new soup, I prefer to:

- a) follow a documented recipe
- b) call a partner for clarification
- c) follow my abilities and testing as I cook

15. I like:

- a) watching films and looking at art works
- b) listening to music, the radio or speaking to friends
- c) participating in sporting activities, eating delicious foods and drinks or dancing

16. I spent most of my time:

- a) watching television
- b) conversing with friends
- c) making things with my hands

17. I first observe how people:

- a) look and dress
- b) sound and talk
- c) stand and their steppings

18. If I am angry, I tend to:

- a) keep replaying in my mind what it is that has annoyed me
- b) raise my voice and tell people how I feel
- c) stamp about, slam doors and physically demonstrate my anger

19. I remember things better by:

- a) jotting points or keeping printed details
- b) speaking them aloud or saying words many times and key points offhand.

c) engaging in activity or envisaging how it being done

20. If I have to complain about fake item, I am most comfortable:

a) writing a letter

b) complaining over the phone

c) taking the item back to the store or posting it to head office

Adapted from Chislett & Chapman (2005)

APPENDIX IX

TEACHERS' GUIDE FOR EXPERIMENTAL GROUP 1

Introduction

In order to enhance quality of teaching and learning of chemistry in this 21st century that is characterized by the use technological gadgets such as computer. Computer-based concept mapping is advocated. Construction of concept map by the aid of computer is referred to as computer-based concept mapping. Representation and organization of knowledge in a graphical form is concept map. The concepts are in the circles or boxes with linking words or phrases between two concepts to show the relationship between the concepts. It is a Schematic and organized way of representing information that provides students and teachers an effective tool to organize, summarize and communicate their knowledge about any concept to stimulate meaningful learning.

The mental images we have for words are our concept of such words. Concept words may be either event or object. Examples of event words are boiling, cooking, heating and weighing while object words are thermometer, litmus paper, refrigerator e. t. c. There are link words (e.g. is, for, can, be, for, by, as, with, are etc that are used together with concept words to form meaningful propositions/sentences. Proper nouns which are names of specific people, places, objects or events are used to label specific event or objects while concept words are used to label regularities in object or events. When two or more concept words are linked together to produce a new idea, a proposition is formed e.g. Compounds are matter.

For the purpose of this study, computerized instructional package on concept map has been design to teach the concept of the rate of chemical reactions. From New School Chemistry textbook by O.Y Ababio (Pages 250 - 264), key concept words and link words that are very important to the understanding of rate of chemical reactions have been identified. The concepts were in a ranking order of which the most general concept is at the top and the least general or concrete concept is below.

The package has three important tabs for user's access; the first tab is tagged as concept mapping, when it is clicked, there will be display of lesson1, lesson 2 and lesson 3. These lessons are rate of chemical reactions, factors that affect the rate of chemical reactions and catalysts. Each of these lessons is represented by using hierarchical type of concept map. The element that appears first in all the lessons is the main concept with (+) inscription. By clicking on the "(+)" allows the user to access subordinate concepts from the main concepts. By clicking on "(-)", it allows user to hide subordinate concepts under main concept for progressive evaluation. The arrow signifies the link nodes. These arrows connect the parent node to the child node. The nodes are movable and responsive.

Magnifying glass is at the top right corner of the page that helps user to zoom in on elements and nodes. User can toggle the app to full screen mode by pressing f 11 on the computer system keyboard or by double clicking on any part of the app where there is no map. Double clicking on the map can also result into full screen mode. The second and the third tabs are "about" and "get help" respectively. The "about" describes what the package is all about while the "get help" is how to use the package. The teacher then

follows the steps in lesson plan on rate of chemical reactions by using the concept maps to teach the three lessons.

APPENDIX X

TEACHERS' GUIDE FOR EXPERIMENTAL GROUP 2

Introduction

In order to enhance quality of teaching and learning of chemistry in this 21st century that is characterized by the use technological gadgets such as computer. Computer-based mind mapping is needed. Construction of mind map through the medium of computer is referred to as computer-based mind mapping. Mind map is a tool for representations that are constructed to represent an individual's, concept and information about a certain topic in mind, using graphs, key words, images and diagram in a two-dimensional environment to show relationship between them.

Mind map utilizes the right and left hemispheres of the brain in order to generate ideas. The cerebral cortex of the brain made up of left and right sides of the brain. The left side of the brain focuses mainly on the cortical words, logic, lists, analysis and numbers while the right side of the brain focuses on such cortical words like rhythm, imagination, color, images, dimension and day dreaming. Therefore, the use of mind map becomes exciting in teaching and learning processes in the sense that it involves using color, images and key words within a mind map linking and associating.

For the purpose of this study, computer-based instructional package on mind map has been developed to teach the concept of the rate of chemical reactions. The main topic which is level 1 is at the centre of the map and sub levels 2 are drawn out from the circle with straight lines. Each of these sub levels has different colors of its own line in order to differentiate different ideas and images are used to enhance remembrance. Sub levels 3 are drawn from sub levels 2 etc. Single strong words and simple meaningful phrases are used for information to avoid words clustering the map.

The package has three important tabs for user's access; the first tab is tagged as mind mapping, when it is clicked, there will be display of lesson 1, lesson 2 and lesson 3. Library type of mind map was used to represent each of these lessons. The main concept is at the centre associating with other ideas (sub-concepts) in a spatial arrangement.

The sub-concepts are depicted with images for the teacher to buttress his explanation during the teaching process. The user can zoom in on the elements using CTRL and (+), zooming out can also be done by using CTRL and (-) for window user. The user can also toggle to the right, left, up and down by using the arrows on the keyboard. The second and the third tabs are "about" and "get help" respectively. The "about" describes what the package is all about while the "get help" is how to use the package. The teacher then follows the steps in lesson plan on rate of chemical reactions by using the mind maps to teach the three lessons.

APPENDIX XI

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

Dear Sir/Ma

I am thrilled to inform you that you have been chosen to participate in a research study. On this note, your consent is hereby needed to take part in the study. Comprehensive information about the research is provided below. If you are willing to participate in the study, kindly endorse this consent form after reading about the research.

Purpose of the Research: The purpose of this study is to determine the comparative effects of computer-based mapping strategies on the students' achievement and interest in chemistry in Ilorin Kwara State. This is to find out a better learning strategy that will improve students' achievement and interest in chemistry.

Procedure: student participants would be taught a selected concept (rate of chemical reaction) in chemistry. They would also be required to answer the multiple-choice test items and fill the inventory interest scale before and after the completion of the exercise.

Confidentiality: Information provided by the students would be strictly used for the purpose of research and treated with maximum confidentiality.

Risk: The procedure will take place in the school within the school hours. Therefore, no risk is envisaged to you as a person during the research.

Benefit: Your participation would offer you chance to have idea of better teaching strategy that could improve student's achievement and interest in chemistry. It would also help to prepare students to perform excellently in both internal and external examinations.

Right of Volunteers: Your participation in the study is voluntary and is not a legal bond. The implication is that your decision not to take part or to stop your participation in this research at any time would not attract punishment or lose anything.

For any enquiry, you may contact the Department of Science education, Faculty of Education, University of Ilorin, Ilorin, Nigeria, or call 08132689636.

Teacher's Respondent Agreement: I hereby voluntarily consent to participate in the research. It is clear to me that I will lose nothing neither will I be punished if I refuse to participate or stop my participation in the research at any time.

I also have knowledge of my privilege to contact Department of Science Education University of Ilorin, Ilorin, Nigeria or call the researcher through the number 08132689636 for any enquiry.

.....
Teacher participant

.....
Signature and date

.....
Researcher

.....
Signature and date

APPENDIX XII

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

Dear Student,

I am elated to inform you that you are selected to participate in a research study. On this note, your consent is hereby needed to take part in the study. Comprehensive information about the research is provided below. If you are willing to participate in the study, kindly endorse this consent form after reading about the research.

Purpose of the Research: The purpose of this study is to determine the effects of computer-based mapping strategies on the students' achievement and interest in chemistry in Ilorin Kwara State. This is to find out a better learning strategy that will improve students' achievement and interest in chemistry.

Procedure: You will be taught a selected concept (rates of chemical reactions) in chemistry. You will also be required to answer the multiple-choice test items and fill the inventory interest scale before and after the completion of the exercise.

Confidentiality: Information provided by you will be strictly used for the purpose of research and treated with maximum confidentiality.

Risk: The procedure will take place in the school within the school hours. Therefore, no risk is envisaged to you as a person during the research.

Benefit: Your participation would be of benefit to you in the sense that it will help you to learn meaningfully and assisting you to obtain good grade in West Africa Senior School Certificate Examination (WASSCE) and other public examinations required for admission into higher institution of learning.

Right of Volunteers: Your participation in the study is voluntary and is not a legal bond. The implication is that your decision not to take part or to stop your participation in this research at any time would not attract punishment or lose anything.

For an enquiry, you may contact the Department of Science education, Faculty of Education, University of Ilorin, Nigeria, or call 08132689636.

Student's Respondent Agreement: I hereby voluntarily consent to participate in the research. It is clear to me that I will lose nothing neither will I be punished if I refuse to participate or stop my participation in the research at any time.

I also have knowledge of my privilege to contact Department of Science Education University of Ilorin, Ilorin, Nigeria or call the researcher through the number 08132689636 for any enquiry.

.....
Student participant

.....
Signature and date

.....
Researcher

.....
Signature and date

APPENDIX XIII

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

Dear Parent,

I am pleased to inform you that your Child/ward has been selected to participate in a research study. On this note, your consent is highly needed to allow him/her to take part in the study. Comprehensive information about the research is provided below. If you want him/her to participate in the study, kindly endorse this consent form after reading about the research.

Purpose of the Research: The purpose of this study is to determine the effects of computer-based mapping strategies on the student's achievement and interest in chemistry in Ilorin, Kwara State. This is to find out a better learning strategy that will improve students' achievement and interest in chemistry.

Procedure: Your Child/ward will be taught a selected concept (rates of chemical reactions) in chemistry. She/he will also be required to answer the multiple-choice test items and fill the inventory interest scale before and after the completion of the exercise.

Confidentiality: Information provided by your child/ward would be strictly used for the purpose of research and treated with maximum confidentiality.

Risk: The procedure will take place in the school within the school hours. Therefore, no risk is envisaged to the students during the research.

Benefit: The likely benefit to your child/ward is to promote his/her achievement and interest in chemistry.

Rights of volunteers: Your child/ward's participation in the study is voluntary and is not a legal bond. The implication is that his/her decision not to take part or to stop his/her participation in this research at any time would not attract punishment or lose anything. For any enquiry, you may contact the Department of Science education, Faculty of Education, University of Ilorin, Ilorin, Nigeria, or call 08132689636.

Parent's Respondent Agreement: I hereby voluntarily consent to allow my child/ward to participate in the research. It is clear to me that my child/ward will lose nothing neither will he/she be punished if he/she refuses to participate or stop his/her participation in the research at any time.

I also have knowledge of my privilege to contact Department of Science Education University of Ilorin, Ilorin, Nigeria or call the researcher through the number 08132689636 for any enquiry.

.....
Parent participant

.....
Researcher

.....
Signature and date

.....
Signature and date

APPENDIX XIV

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

Dear Sir/Ma,

OKEWANDE, Esther Oyeniwe, a postgraduate student of the Department of Science Education, University of Ilorin, Nigeria, is currently embarking on a Ph.D. research work entitled: Effects of computer-based mapping strategies on students' achievement and interest in chemistry in Ilorin, Kwara State, Nigeria.

The purpose of this study is to seek for a better learning strategy that will improve student's academic achievement and interest in chemistry.

On this note, the purpose of this form is to seek your consent for the participation of your students in this study, which will be conducted in your school during school hours only. Any information obtained will be treated with maximum confidentiality and used for research purpose only.

Principal's Respondent Agreement: I hereby voluntarily consent the participation of my students in the research. I have clear understanding that for any enquiry about the research, I may contact the Department of Science Education, University of Ilorin, Ilorin, Nigeria or call the researcher through the number 08132689636.

.....
Principal

.....
Signature and date

.....
Researcher

.....
Signature and date

APPENDIX XV

SUMMARY OF REPORT OF PRELIMINARY FIELD STUDY

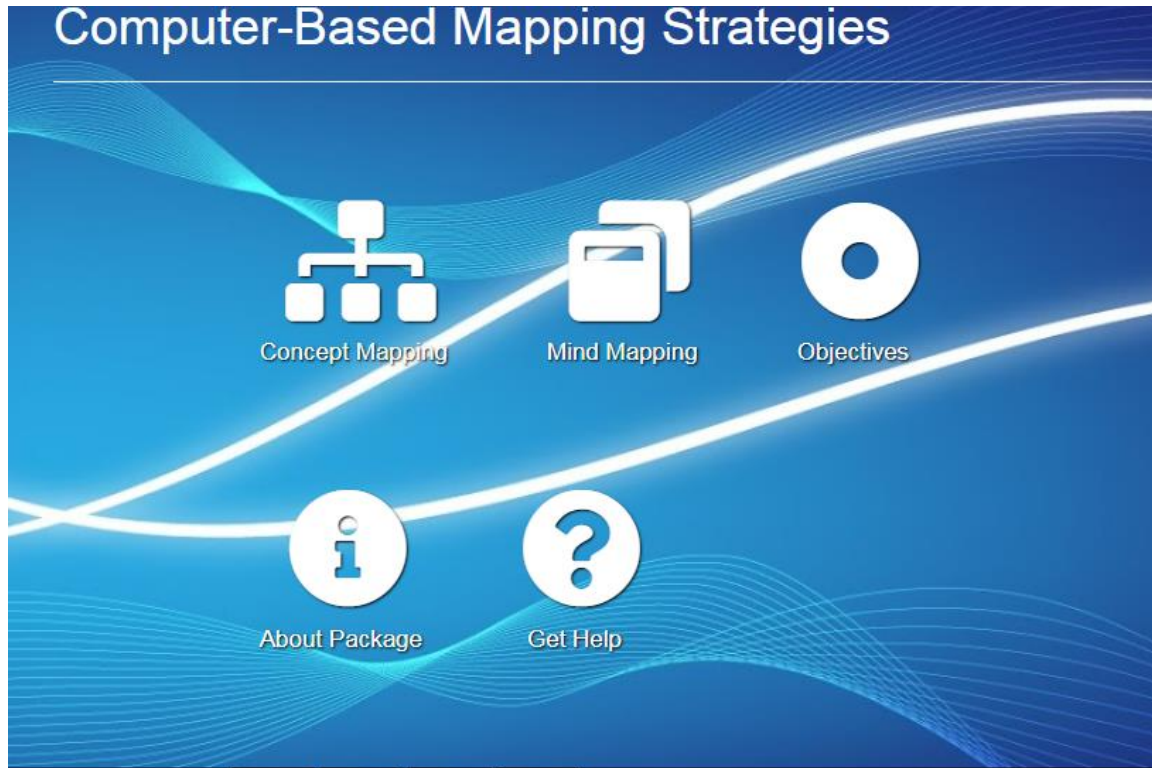
Name of School	No of Functional Computers	No of SS2 Chemistry Students	Projector	Source of Power
1. School A	100	95	Available	Generator
2. School B	98	62	Not available	PHCN
3. School C	1	55	Not available	Generator
4. School D	10	180	Available	Solar
5. School E	7	83	Not available	Generator
6. School F	1	92	Not available	Not available
7. School G	4	28	Available	Generator
8. School H	25	107	Available	Generator and Solar
9. School I	28	75	Not available	Generator
10. School J	8	39	Not available	Generator
11. School K	111	190	Available	Generator and Solar
12. School L	4	44	Not available	Generator
13. School M	60	200	Available	Generator
14. School N	1	60	Not available	Not available
15. School O	43	138	Available	Solar
16. School p	40	61	Available	PHCN/Generator

APPENDIX XVI

SCREEN SHOT OF COMPUTER-BASED CONCEPT AND MIND

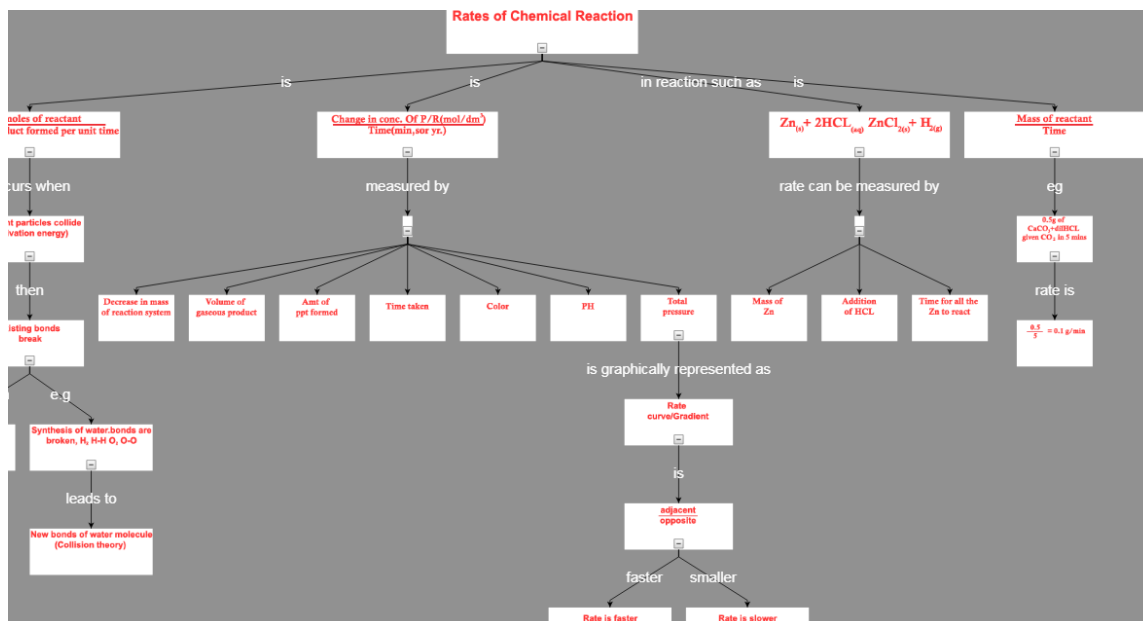
MAPPING INSTRUCTIONAL PACKAGE

HOME PAGE

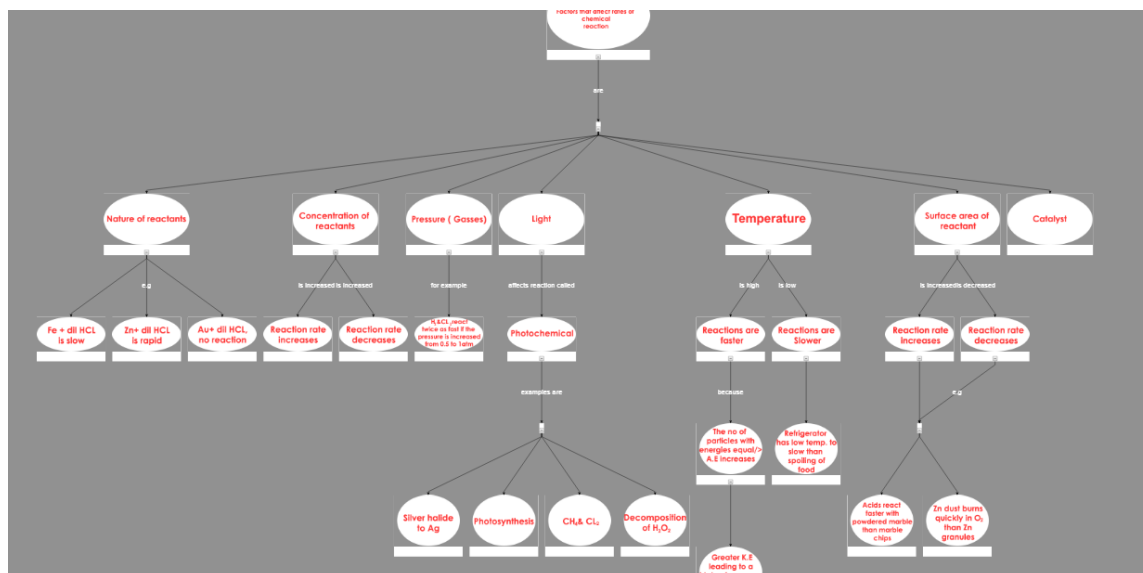


CONCEPT MAPPING

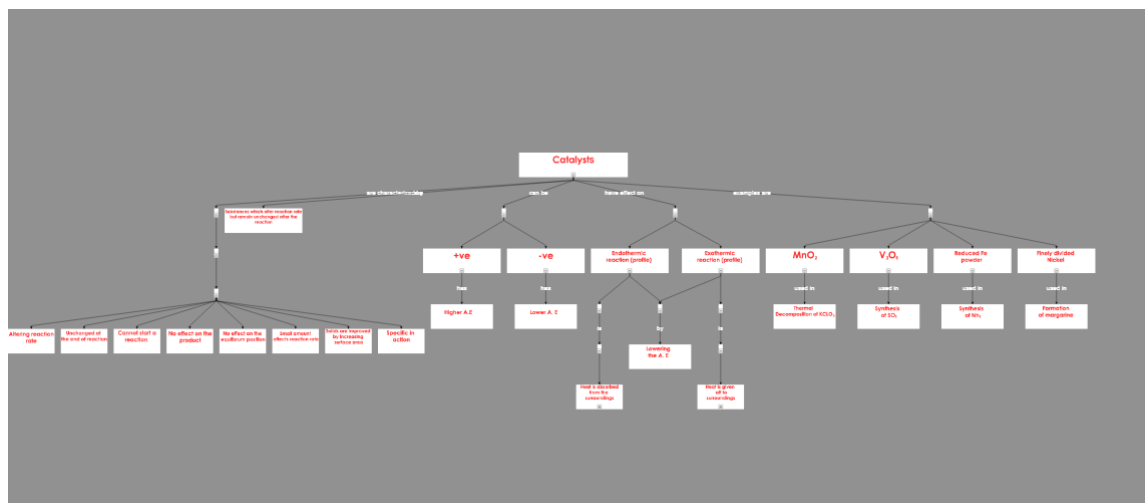
FIRST PERIOD



SECOND AND THIRD PERIOD

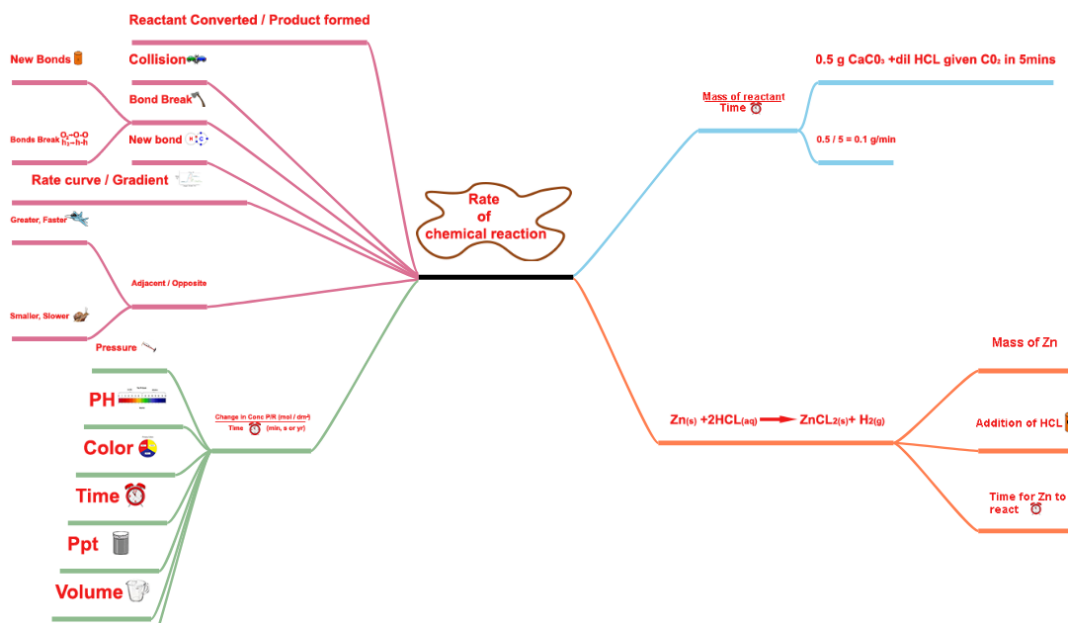


FOURTH AND FIFTH PERIOD

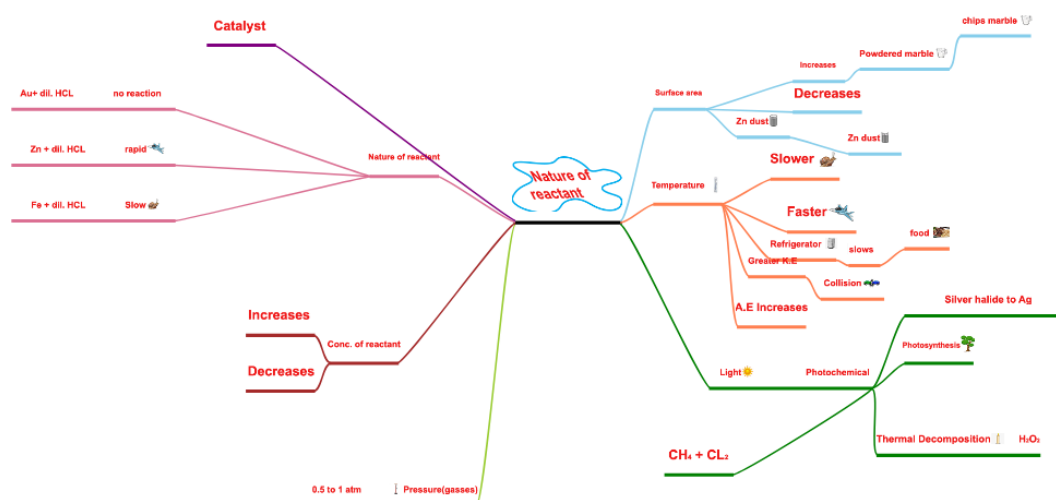


MIND MAPPING

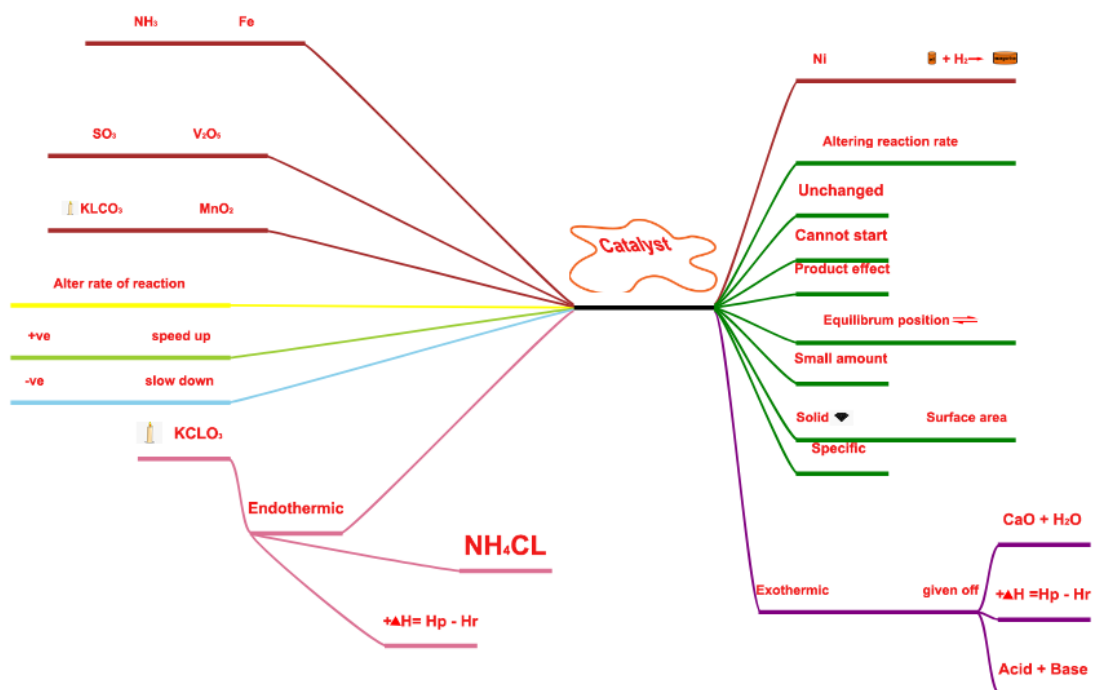
FIRST PERIOD



SECOND AND THIRD PERIOD



FOURTH AND FIFTH PERIOD



APPENDIX XVII

DISSEMINATION OF RESULTS

The major findings emanated from this study may be disseminated as follows:

Journal Publication: The results of this study will be published in reputable journals of high academic standard such as science-based journals, and journal of Science Teachers Association of Nigeria.

Organization of Seminars: Periodic seminars will be organized by the researcher in collaboration with the stakeholders in teaching profession in order to sensitize the teachers to know the benefits of teaching chemistry concepts with more innovative instructional strategies such as computer-based concept and mind mapping strategies.

Workshops: The researcher would also organize workshops on the use of computer-based mapping strategy and how it can be integrated into teaching and learning of chemistry.

Social Media Involvement: The researcher will make use of the social media by hosting the instructional packages on a website where chemistry teachers and students can access the site and learn more about the concept of rates of chemical reactions.

APPENDIX XVIII

COMPUTER-BASED MAPPING INSTRUCTIONAL PACKAGE RATING SCALE

NAME:.....

AREA OF SPECIALIZATION:.....

QUALIFICATION:.....

PHONE NUMBER:..... SIGNATURE & DATE:.....

S/N	Components	Ratings					
		0	1	2	3	4	5
1.	The content is reliable						
2.	Balanced presentation , logical progression and sequential of information						
3.	Correct use of grammar						
4.	Design of the package is based on reliable learning and instructional theories and is directly related with the content of the curriculum						
5.	The content is structured into small segments in a clear and understandable manner						
6.	The structure of the package permits learners to advance, review, see examples, repeat the unit, or escape to explore another unit						
7.	The package promotes collaborative learning						
8.	The package provides opportunities for interaction						
9.	Screens are designed in a clear and understandable manner						
10.	The presentation of information can captivate the attention of students						
11.	There are instructions on the use of the package						
12.	The package gives room for progressive evaluation						

APPENDIX XIX

BUDGET PROPOSAL

Description of items	Expected from			Total
	Sponsor	Student	Others	
1.0 Personal Costs/Allowances				
1.1 Research Assistants (3)		Student		30,000
1.2 3 Research Information		Student		30,000
1.3 Technical Assistants (3)		Student		30,000
Sub-total (not>30% of budget)				90,000
2.0 Equipment (List & Specify)				
2.1 Laptop HP		Student		150,000
2.2 Printer		Student		30,000
2.3 Flash Drive		Student		5,000
2.4 Modem		Student		7,000
Sub-total				192,000
3.0 Supplies & Consumables				
3.1 Textbooks		Student		20,000
3.2 Toner		Student		11,000
3.3 Paper		Student		20,000
3.4 Monthly Subscription of Data Bundle at 3000 x 30 months		Student		90,000
Sub-total				141,000
4.0 Data Collection Analysis				
4.1 Analysis		Student		20,000
4.2 Test Administration and Data Collection		Student		20,000
4.3 Instructional Package		Student		80,000
Sub-total				120,000
5.0 Travels				
5.1 Researcher		Student		15,000
Sub-total				15,000
6.0 Dissemination				
6.1 Seminar 1(Proposal)		Student		60,000
6.2 Seminar 2 (Small Panel)		Student		25,000
6.3 Seminar 3 (Mock Defence)		Student		20,000
6.4 Seminar 4 (Oral Defence)		Student		300,000
6.5 Conference		Student		30,000
6.6 Journal Publication		Student		25,000
Sub-total				460,000
7.1 Miscellaneous		Student		100,000
GRAND TOTAL				1,018,000

APPENDIX XX

Ph.D. Research Schedule and Timeline

MONTH	24/01/2017	24/02/2017	24/03/2017	24/04/2017	24/05/2017	24/06/2017	24/07/2017	24/08/2017	24/09/2017	24/10/2017	24/11/2017	24/12/2017	24/01/2018	24/02/2018	24/03/2018	24/04/2018	24/05/2018	24/06/2018	26/07/2018	24/08/2018	24/09/2018	24/10/2018	24/11/2018	11/12/2018	24/01/2019	24/02/2019	24/03/2019	26/06/2019	24/03/2020	24/04/2020
TASK	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Survey of Literature																														
Write proposal																														
Gather Data																														
Thesis Writing																														
Write Introduction																														
Revise Introduction																														
Writing Methodology																														
Revise Methodology																														
Approval for Proposal Seminar																														
Proposal Presentation																														
Effecting Proposal Corrections for Protocol																														
Protocol Presentation																														
Effecting Correction of Protocol Defence																														
Gathering Data & Analysis of Data																														
Write Results and Discussion																														
Write Conclusion and Recommendations																														
Interim Report																														
Corrections																														
Oral Defence																														
Printing and Binding																														