UNIVERSITY OF EDUCATION, WINNEBA

THE EFFECT OF DIGITAL MEDIA ON SENIOR HIGH SCHOOL STUDENTS' PERFORMANCE IN ORGANIC CHEMISTRY NOMENCLATURE

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DECLARATION

Candidate's Declaration

I, **Nelson Adjei Kumi**, declare that this thesis except quotations and references contained in published works which have been duly acknowledged, is entirely my original research and that no part of it has been presented for another degree in this university or elsewhere.

Signature: ……………………..……..………

Date: …………………………………………

Supervisors' Declaration

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

Name: Prof. John K. Eminah

Signature: ……………………………………

Date: …………………………………………

DEDICATION

I dedicate this work to my adorable parents, Mr. Andrew Asare Kumi and Mrs.Rosina Adutwumwaa Kumi for their support and prayers that have brought me this far.

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ABSTRACT

The study investigated the effect of digital media on the academic performance of senior high school students in organic chemistry nomenclature. It was carried out in the Central Region of Ghana. The research study adopted the non-equivalent quasi-experimental research design using the pre-test and post-test design. The sample comprised 103 students from Potsin Senior High School and Winneba Senior High School who were selected on purpose. Form 3 science students from Potsin Senior High school were forty-eight (48) in number which formed the control group of the research. Fifty-five (55) form 3 science students comprising 31 males and 24 females were drawn from Winneba Senior High School to form the experimental group. A five-point Likert scale questionnaire was administered to both groups before treatment to determine their conception of organic chemistry nomenclature. After, a pre-test was administered to all the participants to determine their performance level in organic chemistry nomenclature. Treatment was administered to the experimental group using digital media and the control group was taught using the traditional method of teaching. After the treatment, a post-test was administered to both groups to determine the effectiveness of the treatment. Another 5-point Likert scale questionnaire was also administered to students of the experimental group to determine their views of digital media in teaching organic chemistry nomenclature. The tests (pre-test, post-test) and questionnaire results were then analysed using Microsoft excel 2019 and SPSS version 25.0 respectively. When the results of the two methods were compared, the digital media was found to be more effective than the traditional method. Results also revealed that there was no differential effect of digital media on male and female students' performance in organic chemistry nomenclature. The responses to the questionnaire proved that the majority of students agreed that digital media is an effective method of teaching organic chemistry nomenclature It is therefore recommended that chemistry teachers should adopt digital media in teaching and chemistry teachers should be made to attend workshops, seminars and conferences to update their knowledge of the methods of teaching concepts in chemistry.

CHAPTER ONE

INTRODUCTION

1.0 Overview

This chapter gives an introduction to the research concept including a preview of background information, a statement of the problem, the purpose of the study, objectives, hypothesis and research questions. Similarly, it contains the significance of the study, issues limiting and delimiting the study and the organisation of the study.

1.1 Background to the Study

Chemistry is one of the science subjects offered in the secondary school curriculum in Ghana. An analysis of the secondary school chemistry syllabus shows that students are required to master introductory concepts related to inorganic chemistry, physical, analytical and organic chemistry (MOE, 2002) all of which are tested at semester examination. According to the syllabus, Organic chemistry requires that students master concepts related to nomenclature, nature, properties and uses of organic substances grouped in different families as well as those of their products. According to Sirhan (2007), organic chemistry is essential in new compounds and enhancing those compounds on which mankind has increasingly become reliant. This assertion is also supported by Twoli (2006) who opined that this subject area is very important, not only to those who are interested in science-related careers but also to every individual living today and to future generations. Chemistry curricula mostly integrate many abstract concepts most of which though essential to further learning in both chemistry and other sciences, most students find difficult to comprehend (Sirhan, 2007; Taber, 2002). One of the essential characteristics of chemistry is the constant interplay between the macroscopic and microscopic levels of thought and it is this aspect of chemistry learning that represents a significant challenge to novices ((Sirhan, 2007).

Green (2002) in his proposition based on an analysis of the content of chemistry sub-disciplines found that teachers also have challenges with pedagogical approaches for instruction which result in students' poor concept formation and subsequently poor performance in the subject area. Taber (2002) and Zoller (1990) on their part have suggested that the abstract nature of organic chemistry along with other content-related learning difficulties means approaches that equip students with high-level skill sets to be adopted. Likewise, Skemp (1987) and Jaji (1994) posited that learning chemistry should be student-centred, participatory and problem-solving in approach. In an attempt to be in tune with the current prevailing computer literacy era, World Bank (2007) suggested in its report that science curriculum has to be taught through modern system such as digital media so that learning can be enhanced and more curiosity and enthusiasm created in the students.

Other researchers through their observations and research studies have called for the adoption of experiential-based teaching methods such as digital media instruction (DMI) as a way of enhancing universally-connected academic societies (Bereiter, 2002; World Bank, 2007). Digital media generally incorporates photographs, videos, audio clips, animations, software and learning management systems (LMS) to be utilized via mobile devices, tablets, or computers (Heo, 2009; Melton & Burdette, 2011; Ungerer, 2016; Yousef, Chatti, & Schroeder, 2014). Linn, Chang, Chiu, Zhang, and McElhaney (2010) observed that digital media platforms can help students link abstract representations of scientific phenomena cognitively. Cotton (1991), found out that digital media instruction (DMI) improves concept formation exponentially with students learning as much as 45% quicker and possessing better retentive memory leading to more positive interest and performance than colleagues who were taught through conventional methods of instruction. Digital media instruction platforms also strengthen the teaching of chemistry generally (Ezeudu & Ezinwanne, 2013; Garanga, Amadalo, Wanyonyi, Akwee & Twoli, 2012). Mathews and Secombe (2005) found that computer- animated instruction (computer graphics) is an effective conceptual change strategy in teaching electrochemistry in comparison to the conventional method of instruction. Other positive outcomes of digital media-supported instructional platforms include the use of eChem to help students construct models and translate chemical representations (Hoffman, Wu, Krajcik & Soloway, 2003), In all these cases, it was reported that students in groups which were exposed to DMI tools scored significantly higher than those exposed to conventional methods of instruction. However, the usage of Digital media in teaching organic chemistry nomenclature is limited in the existing literature. It is against this background that the study is being conducted to examine its effectiveness in improving SHS students' academic performance in organic chemistry nomenclature.

1.2 Statement of the Problem

Chemistry appears to be taught in Ghana's Senior High Schools through lectures, note-taking, chalkboard illustrations, demonstrations, and other teacher-centred techniques. However, these teaching methods have not yielded the expected results. Students have continued to yield poor results in chemistry year in and year out (WAEC, 2018). Erduran and Scerri (2003) for instance stated emphatically that learning chemistry poses a challenge to a majority of students, particularly in its sub-disciplines which include inorganic chemistry, organic chemistry and physical chemistry. Several researchers have acknowledged that many students find mastery of topics related to organic chemistry to be difficult (Ryles, 1990; Schmidt, 1992; Shani & Singerman, 1982; Simpson, 1983). For Ghanaian students, WASSCE results analysis for Paper II in chemistry in the last five years shows that questions testing organic chemistry concepts were among some of the most challenging for candidates at the end of the subject examination (WAEC, 2010; WAEC, 2012; WAEC, 2013). Having explored the potential of Digital media instruction as a useful method, this research sought to determine whether it would help improve the academic performance of chemistry students in expressing organic chemistry nomenclature.

1.3 Purpose of the study

The purpose of this study was to determine the effect of digital media instruction on senior high school chemistry students‘ academic performance in expressing organic chemistry nomenclature.

1.4 Research Objectives

The objectives of the study were to determine:

1. Students‘ conceptions of organic chemistry nomenclature.
2. The effect of digital media instruction on students‘ academic performance in expressing organic chemistry nomenclature.
3. The differential effect of digital media instruction on the male and female experimental group of students‘ performance in expressing organic chemistry nomenclature.
4. The views of the students on the use of digital media for instructions in expressing organic chemistry nomenclature.

1.5 Research Questions

The following research questions were addressed in the study;

1. What are students' conceptions of organic chemistry nomenclature?
2. What is the effect of digital media on students' performance in expressing organic chemistry nomenclature?
3. What are the differential effects of digital media on the experimental group of male and female students' performance in expressing organic chemistry nomenclature?
4. What are the views of students on the use of digital media for instructions in organic chemistry nomenclature?

1.6 Null Hypotheses

The following null hypotheses H_O were tested for statistical significance;

H_O 1. There is no statistically significant difference in the academic performance of the experimental and control group of students before the treatment.

H_O 2. There is no statistically significant difference in the academic performance of the experimental and control group of students after the treatment.

H_O 3. There is no statistically significant difference in the mean performance of the male and female experimental group of students.

1.7 Significance of the Study

The outcome of the study will be very important in the teaching and learning of organic chemistry in senior high schools.

It will identify the problems associated with the lack of understanding of pre-requisite concepts by students which make it difficult for them to study and understand theoretical phenomena in organic chemistry at senior high levels.

It will also assist teachers and students to take appropriate steps that will enable them to teach and learn basic organic chemistry phenomena effectively.

The study will also inform the teachers to use technology, visual supporting tools, the smart board, computer graphics etc. to make teaching and learning of concepts in organic chemistry more comprehensible.

It will also help future researchers to investigate more into the topic in find out some other learning difficulties in chemistry that will not be captured under this study.

1.8 Limitations of the study

The health status, mood and test anxiety of the research participants may influence their response to the data collection instruments.

1.9 Delimitations of the study

This study will delimit itself to several parameters that focus on the integration of digital media in the teaching and learning of organic chemistry. These include:

Respondents would be drawn from selected schools in Effutu Municipality and its environs. Only schools which are equipped with computers and Information technology-related facilities would be involved in the study. The study would be confined to public secondary schools only. The study will focus specifically on the integration of digital media in the teaching and learning of organic chemistry within the secondary school curriculum, although digital media can potentially be used for all subjects within the existing curriculum.

1.10 Organization of the Study Report

The study report will be divided into five chapters: The first chapter will be the introduction to the study. The second chapter will cover a review of related literature. The third chapter will outline detailed information on the research methodology. The fourth chapter will look at the data that will be collected and how the data can be analyzed. The fifth chapter will cover a discussion of the results, a summary of the study, a conclusion and recommendations.

1.11 Definition of Terms

Digital media: It involves incorporating multiple digital software, devices and platforms as a tool for learning.

Chemistry: The branch of science that deals with the study of matter.

Conventional instruction methods: It is the instructional strategy used in teaching the control group that involves the theoretical explanation of concepts and facts on nomenclature and properties of organic compounds.

Effect: It is the outcome that follows exposure to some sort of intervention

ICT integration: Use of ICT tools to aid classroom learning process.

Dual coding: It is a theory that postulates that both visual and verbal information when used to represent information enhances learning.

Performance in Chemistry: The competency level attained in Chemistry measured in terms of grades a student scores at WASSCE level.

Higher Order Skills: Skills associated with metacognitive, reflective, critical, logical and creative thinking.

Public Schools: A tuition-free school, funded and operated by the government

Technology: The theory and practice of design, development, utilization, management, and evaluation processes and resources for learning.

1.12 Abbreviations and Acronyms

ANOVA	Analysis of Variance
BOM	Board of Management
DMI	Digital media Instruction
DML	Digital media learning
HOD	Head of Department
GOG	Government of Ghana
ICT	Information Communication and Technology
IT	Information Technology
IWB	Interactive White Board
WAEC	West Africa examination council
MDG	Millennium Development Goals
MOE	Ministry of Education
NEPAD	New Partnership for Africa's Development
PTA	Parents Teachers Association
SCAT	Students Chemistry Achievement Test
SPSS	Statistical Packages for the Social Sciences
MP	Member of Parliament
OSA	Old students' association
SHS	Senior High School
IUPAC	International Union of Pure and Applied Chemistry
WASSCE	West Africa senior school certificate examination

CHAPTER TWO

LITERATURE REVIEW

2.0 Overview

This chapter will review and discuss issues in the literature relating to learning difficulties in organic chemistry. The review will look briefly at the conceptual understanding of organic chemical concepts using technology and the role of constructivism in teaching and learning concepts in organic chemistry. This review will seek to bring together some of the main findings from research over the past few decades attempting to establish some key general principles which may be of value to curriculum development, policymakers, teachers, and teaching strategies as well as in the generation of more research work.

The following review and discussion of related literature are organized in areas such as:

1. Theories of knowledge construction
2. Conceptual Framework
3. Concept of students‘ Performance
4. Measurement of academic performance
5. Conceptual understanding of students in organic chemistry nomenclature
6. Diagnosing students‘ conceptions of organic chemistry nomenclature
7. Concept of dual-coding learning
8. WAEC chief examiners‘ report on IUPAC nomenclature of organic compound
9. Instructional Content
10. Teachers‘ philosophy and use of DMI tools
11. Introduction to IUPAC nomenclature of organic compounds
12. Students‘ factors and the use of DMI tools

13. Teachers‘ factors and the use of DMI tools

14. Institutional factors and the use of DMI tools

2.1 Theoretical Framework

This study is based on Kolb‘s learning cycle theory. Kolb‘s (1976) theory describes the sequential stages of learning as knowledge, experience and skills acquisition. This mode of learning is called _experiential learning‘ or learning by practice and this is in line with constructivist learning. The sequential stages are watching, thinking, practicing and feeling and these stages are linked to each other.

- Watching (reflective observation)
- Thinking (abstract conceptualization)
- Doing (active experimentation)
- Feeling (concrete experience)

In Kolb‘s learning cycle, four stages of learning are identified. Students are exposed to new experiences. Furthermore, students must make time and space to reflect on their new experiences from a different point of view. (Reflective observation).

Students can form, reform and process their ideas, take ownership of them and integrate their new ideas into sound logical theories (abstract conceptualization). Students need comprehension to make decisions, solve problems and test their knowledge in new situations (active experimentation). These activities catalyze the learning processes to the next round. (Concrete experience).

Students tend to differ in their abilities, approaches and preferences to learning due to personality, cognitive processes and prior learning experiences. This theory is perfectly linked to the present study in that for every student to draw, name an organic aliphatic compound and also know the properties of the compound, he or she has to watch the compound to be drawn critically and think about it before drawing and naming is made. A good drawing and naming of organic structures will lead to a concrete experience.

Figure 1 represents the learning cycle theory by Kolb (1976):

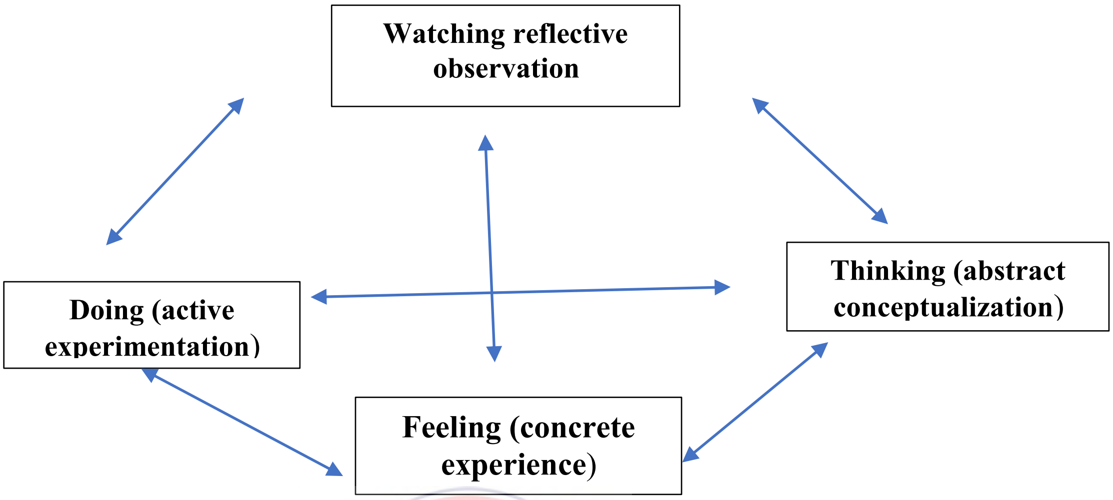

Figure 1: Kolb's learning cycle theory

Source: Kolb (1976)]

2.2 Conceptual Framework

The study intends to compare the effect of the use of digital media and conventional methods of instruction in organic chemistry. It was hypothesized that performance in organic chemistry is influenced by the teaching strategy employed by teachers and school-related factors. It is indicated that digital media packages can transform the way students assimilate, accommodate and learn concepts (Leonard, 2002). The researcher posited that digital media provides a variety of visual presentations that support the new inquiry-based approaches to science instruction, providing virtual or field learning experiences which are more appropriate for learning than the somewhat one-dimensional world of conventional methods. It, therefore, opens up new perspectives for students of all abilities, more so for students who find theoretical explanations of concepts more difficult to comprehend.

The key concepts in chemistry have become easier with the advancement of science and technology, allowing the learning of chemistry to be interesting and rewarding. Basic chemistry is relevant hence, one can choose to take any of the sciences because all of the sciences involve matter and the interactions between types of matter. Students who wish to become chemists, doctors, geologists, nurses, nutritionists, pharmacists, and physicists should study chemistry. Chemistry-related jobs are many and high-paying, hence, one might want to make a career in chemistry. The importance of chemistry will not be diminished over time, so it will remain a promising career path.

It is a well-established fact that many students find it difficult to understand basic organic chemistry concepts because, chemistry is a multifaceted discipline, requiring complex thinking and reasoning. Therefore, the necessity of incorporating more visual materials into chemistry lessons.

One of the most promising means of teaching and learning Science is the Internet. People's understanding of what computers can do has shifted dramatically as the size and cost of these devices have decreased while their power has increased. It is possible to acquire information through computers and the internet in Science, especially in chemistry classes in secondary and higher education. The teaching tools prepared by institutions specializing in such applications could also be used in digital media. By using such teaching tools, students could learn the subject matter in a better way as they are provided with a variety of knowledge. In this case, the role of the teacher is to guide and help the students where necessary. Learning chemistry requires a particular visual understanding. Many chemical concepts can better be understood by using a visual representation of the phenomenon (Rutten, 2012).

2.3 Digital Media

Digital media is a set of technological formats that can either be produced or consumed (Koc & Barut, 2016). Using digital media generally incorporates photographs, videos, audio clips, animations, software and learning management systems (LMS) to be utilized via mobile devices, tablets, or computers (Heo, 2009; Melton & Burdette, 2011; Ungerer, 2016; Yousef, Chatti, & Schroeder, 2014). Digital media has been found to enhance stronger student engagement (Reynolds, 2016). These technologies are encouraged to be used in educational settings by ISTE (2017), which remains the standard in technology-based teaching and learning best practices in the United States (Baek, Keath, & Elliott, 2018).

As generations grow up with digital media in both leisure and academic environments, competency skills and educational standards are increasingly affecting how teachers teach and students learn (Casey et al., 2017; Prensky, 2010; Tiernan, 2015). Students are also expected to implement digital media into their learning experience through critical thinking and the use of contemporary technologies. It is important to acknowledge that both students and teachers will continuously be digital natives (Bodsworth & Goodyear, 2017; Kretschmann, 2015; Prensky, 2010).

However, more could be understood about digital media as a pedagogical tool used between students and teachers in physical science settings (Bodsworth & Goodyear, 2017; Casey et al., 2017; Stapleton et al., 2017). Digital media can be implemented in a combination of formats with a variety of uses. The major digital media formats that were found in the relevant literature and could be applied to organic chemistry included but were not limited to the use of video, audio, learning management system usage as well as social media and virtual worlds.

Audio has also been used to record lessons for students to listen to (Gross, Wright, & Anderson, 2017) and could be used to verbally share and create information. The audio could also be within videos which might require a planned script with intended content and outcomes (Weir & Connor, 2009).

The use of learning management systems could be a repository for video, audio, photographs, and text information used to communicate between teachers and students. Learning management systems are consistently encouraged to be utilized by educators and students which could incorporate other digital media formats as accessibility remains increasingly popular and ever-evolving with personal devices (Cochrane, Antonczak, Keegan, & Narayan, 2014; Melton, Band, Haris, Kelly & Chandler, 2015; Reynolds, 2016; Stapleton et al., 2017; Melchor-Couto, 2019). Physical science subjects have increasingly taken advantage of LMS by incorporating online and hybrid courses for students (Goldstein et al., 2017; Stapleton et al., 2017). It was important to develop proficiency via training that could be completed either online or in-person (Brock et al., 2018). Other digital media include social media, augmented reality, and virtual worlds such as chatrooms or video games (Guse et al., 2012; Melchor-Couto, 2019). The described digital media formats provide the foundational continuum of pedagogical practices that could be adopted within physical science.

However, it is important to recognize that implementing digital media is not a one-size-fits-all adoption plan, particularly among students (Loizzo, Ertmer, Watson, & Watson, 2017). Although this study focused more on pedagogical practices, it was essential to highlight students learning aspects and foundations regarding digital media. Therefore, the remaining sections discuss digital media involvement in student learning and pedagogical practices. Considered to be digital natives, younger generations are immersed in a digitally-bound educational environment (Bodsworth & Goodyear, 2017; Prensky, 2010). Using devices such as iPads or mobile phones and their respective apps, digital natives are highly accustomed to learning from digital devices (Bodsworth & Goodyear, 2017; Oliver, 2016). Digital resources such as educational websites, tutorial videos, and mobile apps provide students with the opportunity to learn by constructing personal inquiries with social experiences (O'Loughlin, Chróinín, & O'Grady, 2013; Reynolds, 2016).

O'Loughlin et al. (2013), is just one example of a learning-by-doing approach (Metzler, 2011; Stackelberg & Jones, 2014). A learning-by-doing approach could include students actively researching information, communicating through discussions among peers and stakeholders, and most importantly, the use of whatever sort of digital media is implemented (Ng, 2015). However, creating environments that promote critical thinking and effective learning depends on the teacher and their administrative practices. Applying digital media technologies in an educational environment is becoming more affordable for pre-tertiaries and tertiaries (Stapleton et al., 2017). With teachers integrating a variety of multimedia (e.g., videos, podcasts), mobile apps, or the use of LMS, digital media is considered an essential practice among secondary schools (Lim et al., 2009; Melton et al., 2015). Institutions that utilize an LMS in subjects allow both the teacher and the students to cross-reference work and promote improved teaching and learning experiences that might not have been communicated otherwise (Melton et al., 2015; Reynolds, 2016; Stapleton et al., 2017).

The possibility to incorporate an LMS as a backup resource or a primary resource give teachers and students open possibilities to utilize digital media technologies (Campbell & Cox, 2018). Pedagogical practices will only continue to grow as digital natives embrace digital media (Prensky, 2010; Tiernan, 2015). The implementation of digital media as a pedagogical practice promotes the transition from a teacher-centred approach to a student-centred learning environment. This approach is considered a best practice for enhancing student performance and developing cognitive skills in a particular subject area. (ISTE, 2017; Kretschmann, 2015; O'Loughlin et al., 2013; Stapleton et al., 2017).).

Furthermore, discussions about digital media instruction in organic chemistry are growing in both empirical and practical literature. Existing literature showed an increase in additional digital media formats in a variety of chemistry-related fields. Digital media implementation also continues to be examined and discussed within the academic community (Goldstein et al., 2017; Lim et al., 2009; Melton et al., 2015 Recent research explored the use of online and mobile software within the academic community (Goldstein et al., 2017; Melton et al., 2015). For example, Melton et al. (2015) evaluated the effectiveness of using educational software to increase student motivation, social support, self-efficacy, and enjoyment in classroom learning. Quantitatively, the study found a significant difference between the treatment and control groups resulting in software-based teaching and learning with higher self-efficacy and peer support. Qualitative findings showed that students valued the learning process as it gave them control of their performance and feedback.

2.4 Theories of Knowledge Construction

For this study, theories of students' knowledge construction such as pedagogical content knowledge, generative learning, and constructivism have been reviewed. This helped to provide insight into how students learn and the challenges, they encounter in the learning processes.

Pedagogical Content Knowledge

According to Bucat (2005), PCK refers to knowledge about the teaching and learning of a particular subject matter taking into account the particular learning demands inherent in the subject matter. There is a difference between a teacher knowing his or her subject matter (content mastery) and knowing about teaching and learning that subject matter (content delivery). Some knowledge about teaching and learning Chemistry is specific to the particular subject matter. From Van-Driel (2021), the concept of Pedagogical Content Knowledge (PCK) pertains to how teachers interpret and transform their subject-matter knowledge to effectively facilitate student learning.

PCK is about the transformation of content knowledge so that it can be used effectively and flexibly between teachers and students during the teaching and learning process. Teachers could deduce PCK from their respective teaching experiences and schooling activities (Van Driel, 2021). Teaching demands some basic skills, subject matter and general pedagogical skills. Teachers' understanding of his or her subject matter is more critical for an inquiry-oriented classroom.

Furthermore, it entails the ability to critically analyze textbooks and curricular documents, engage students' interests, and consider their attitudes and beliefs. The interaction within the classroom is essential, focusing on creating effective communication and utilizing assessment to guide instruction. Moreover, PCK helps in the comprehension of how particular topics or problems are organised, represented, and adapted to the different interests and abilities of students. This is because PCK combines content and knowledge of teaching. Hence, PCK differentiates the understanding of content specialists from that of pedagogues.

According to Van-Driel (2021), Shulman (1987) identified the knowledge of representations of subject matter, comprehension of specific learning difficulties, and understanding of student conceptions as the primary components of Pedagogical Content Knowledge (PCK). These components are interrelated and can be flexibly utilized by teachers. Teachers who possess a diverse range of representations and a strong awareness of learning difficulties are better equipped to effectively deploy their PCK and enhance instruction.

From Van-Driel (2021), there is no one accepted conceptualization of PCK and different components are integrated into PCK among scholars. To them, all scholars however agree on knowledge of representations of the subject matter and understanding of specific learning difficulties and student conception which were the two main components of Shulman‘s PCK. All scholars suggest that PCK is developed through an integrative process rooted in classroom practice implying that prospective or beginning teachers usually have little or no PCK at their disposal. The main distinctive feature of a teacher‘s knowledge base lies at the intersection of his or her content and pedagogy, the ability to transform his or her content knowledge into forms that are pedagogically powerful and yet could be used to benefit all students notwithstanding differences in their abilities and background (Shulman, 1987).

Concerning science teachers‘ PCK, Van-Driel (2021), reported that the combination of specific topic familiarity and teaching experience positively influences PCK. PCK of experienced science teachers may vary considerably notwithstanding them having similar curriculum and content knowledge.

Generative Learning

Students achieve meaningful learning when they actively construct and generate meaning from sensory input, as emphasized by Wittrock (2000). This means that a student needs to construct his or her knowledge and no other person can do it for him or her. Shulman (1987) said that learning is the ultimate responsibility of students. According to Lee, Lim and Grabowski (2001), Wittrock emphasized one very significant and basic assumption, the learner is not a passive recipient of information rather he or she is an active participant in the learning process working to construct a meaningful understanding of information found in the environment. Grabowski (2003) pointed out that Wittrocks' generative learning model integrates various areas of cognitive psychology such as cognitive development, human abilities, information processing, and aptitude treatment interactions. To him, Wittrock's model for generative learning was introduced as a prescribed teaching strategy to reduce reading comprehension strategies according to Grabowski (2003).

The importance of asking the student to generate his or her meaning is summarised by Wittrocks' statement. Although a student may not understand sentences spoken to him by his teacher a student likely understands sentences that he generates himself. The importance of generative learning is knowledge generation. Meaningful knowledge is generated only when the student self-generates the relationships and the understanding (Lee et al., 2001). Wittrock's model of generative learning in which the brain is a model builder consists of attention, motivation, knowledge, preconceptions and generation. The study on the generative learning model was carried out in neural research and generative cognitive function was studied in knowledge-acquisition research (Wittrock, 2000). From Grabowski (2003), there are two important aspects of Wittrock's motivational processes. These are interest and attribution. Attribution, which is the process of giving credit for success or failure to a student's effort could cause him or her to actively learn or not. If a student appreciates that his or her success in a subject or course is a result of his or her effort then he or she will be motivated to exert greater effort next time. Hence, the use of rewards and praise should be done in such a way that students can directly attribute success to their effort.

Arousal and intention in the brain have direct effects on students' learning processes. Within the external environment of students comes arousal and attention that stimulate them internally. The key to Wittrock's learning process is attention. Without attention, learning cannot occur (Grabowski, 2003). Teachers who provide behavioural objectives with questions, as well as interpretations of the relevance of the chosen topic, gain the attention of students during the teaching and learning process. The components of memory are the knowledge-creation processes such as beliefs, concepts, preconceptions, and experiences. Students' comprehension is generated when relationships or linkages are established between environmental stimuli and existing mental structures. According to Grabowski (2003), Wittrock revealed that scientific concepts for example, the IUPAC nomenclature of organic compounds should be thought of early before preconceptions are formed. Teachers should as much as possible link instruction to students' background knowledge and interest. Wittrock (as cited in Grabowski, 2003) said ―the act of generative teaching is knowing how and when to facilitate the students' construction of relations among the parts of the text and their knowledge." An activity is labelled generative when it creates organisational linkages among the various components of the environment. Another generative activity is the one that establishes linkages between the external stimuli and memory components such as demonstrations, pictures and applications. Grabowski (2003) explained that teachers can formulate titles and headings as organizers or ask students to formulate a title or heading. If a teacher intends to provide his or her students with a title or heading, then it should be done in such a way that it would direct students‘ attention.

Lee et al. (2001), established an interrelationship among the components of generative learning mode. According to them, only those activities that involve the actual creation of relationships and understanding could be grouped as examples of generative learning strategies. The student has to construct his or her understanding by restructuring the environmental information. If a student can generate linkages between memory such as preconceptions, abstract knowledge, experience and new information then an understanding of a concept can be generated. In the model, students are encouraged to be mentally actively constructing relationships between schema and new knowledge (Lee et al., 2001). The motivation given to students promotes the impulse and intention to learn. Students‘ interest in knowledge generation could only be sustained if the students attribute successful understanding to their effort. Students use various learning strategies from simple coding to integration strategies to construct the relationship between their memory and the new knowledge whenever they are motivated (Lee et al., 2001). The generation of knowledge should be under the control of students. This is based on the fact that when students are allowed to self-monitor their efforts, they manage their efforts and resources and alter their learning strategies to generate meaning. Grabowski (2003), said that understanding occurs when students can link existing mental structures and new information and not by placing information or transforming information in memory.

Constructivism

Theories of learning which are based on foundations, scope and validity alternative to objectivist theories of knowledge are termed constructivists (Swan, 2005). Thus, both constructivists and objectivists assert that there is the real world which we can experience. In this real-world constructivists believed that students construct meaning as they interact with the physical, social, and mental worlds. Gallagher (2000), said that students should realise that they have to construct their knowledge whenever they are thought any scientific concept. According to Swan (2005), constructivists are divided in the areas of focus though they all share common assumptions about the nature of learning and the construction of knowledge. Some constructivists focus the student‗s knowledge construction on the social environment, physical, and mental world.

Social constructivism:

Social constructivists agree that students construct knowledge through social interactions. Thus, psychologists of today recognise that culture shapes cognitive development by determining what and how students will learn about the world (Swan, 2005; Woolfolk, 2007). Lev Vygotsky, a Russian psychologist, attributed a special role in cognitive development to the social environment of the student. That meaning is constructed by a student socially as he or she indulges in activities, communicates and interacts with others (Swan, 2005; Woolfolk, 2007). The student‗s culture (that is the social world) determines which stimuli occur and are attended to and that knowledge constructed is not predetermined by innate factors. Vygotsky, being a major spokesperson of sociohistorical theory asserted that human activities are placed in a cultural setting and cannot be understood apart from these settings. Therefore knowledge construction is the transformation of socially shared activities into internalised processes (Woolfolk, 2007). According to Swan (2005), Vygotsky considered the construction of knowledge by a student in two sections. First, students construct the knowledge socially and internalise it individually. Vygotsky a social constructivist used three themes: social sources of individual thinking, the role of cultural tools in learning and development and the zone of proximal development. The social sources of individual thinking are based on the fact that students‘ higher mental processes are first co-constructed during shared activities between the student and another person. Then the processes are internalised by the student and form part of his or her cognitive development (Woolfolk, 2007).

According to Vygotsky (as cited in Woolfolk, 2007), cultural tools (such as rulers, pipettes, and computers) and psychological tools (such as works of art, signs, symbols, codes, and language) play vital roles in knowledge construction. Vygotsky was particularly concerned with the role of language in thinking and learning. He pointed out that language and thought were closely related (Swan, 2005). All higher-order mental processes such as reasoning and problem-solving are achieved by psychological tools. Language is crucial to knowledge construction as it provides a way to express ideas and ask questions, and the links between the past and the future. The student‘s ability to plan a solution to an identified problem depends on the language capacity of the student. According to Swan (2005), Vygotsky asserted that there is a fundamental correspondence between thought and speech in terms of one providing resources to the other; language becoming essential in forming thought.

From Swan (2005), the zone of proximal development is the distance between the actual development level as determined by independent problem-solving and the level of potential development as determined through solving under adult guidance or in collaboration with more capable peers. Knowledge construction occurs in this zone.

According to Woolfolk (2007), Vygotsky believed that the role of private speech in cognitive development fit with the notion of the zone of proximal development. Often, an adult uses verbal prompts and structuring to help (or support) a child to solve a problem or accomplish a task. In education psychology, the support and guidance adults give as a child attempts to solve problems beyond his or her current knowledge is referred to as scaffolding (Crowl, Kaminsky & Podell, 2010). This scaffolding can be gradually reduced as the child takes over the guidance, perhaps first by giving the prompts as private speech and finally as inner speech. Dirks (1998) explained that many schools have now realised that knowledge is not objective but constructed socially and that the knowledge constructed depends greatly on the experience and interactions of the students with others who know it.

Cognitive constructivism:

Cognitive constructivism is accredited to psychologists such as Jean Piaget. Cognitive constructivists revealed that knowledge construction should be based on the internal development of mental structures. Cognitive constructivists stressed the students' knowledge, beliefs, self-concept, and inner being of the student. From Swan (2005), Piaget referred to mental structures as schema. The two kinds of cognitive processing involving schema construction are assimilation and accommodation. For a student to assimilate means to incorporate new knowledge into his or her existing mental structures whereas to accommodate means to change his or her existing schema to incorporate a new knowledge that conflicts with it. Piaget pointed out that knowledge construction is influenced by students' genetic make-up and this change as the students mature. From this, Piaget (as cited in Swan, 2005) came out with his stage theory.

The pre-linguistic sensory-motor stage is characterised by kinesthetic understanding and organisation of experience while the pre-operational stage is characterized by egocentrism, the organisation of knowledge relative to oneself. In the concrete operational stage, knowledge is organised in logical categories but still linked to the concrete experience. It is only in the formal operational stage according to Piaget that knowledge is abstracted from experience and formal reasoning can occur. According to Swan (2005), cognitive constructivism is essential to us because it locates knowledge construction in the minds of students and that students should interact with the environment to learn.

Constructionism:

Constructionism is focused on how public knowledge in disciplines such as chemistry is constructed. Hence, social constructionists do not emphasize individual student knowledge construction as in the case of social and cognitive constructivists. From Swan (2005), Seymour Papert recognized the important roles of construction in the world to knowledge construction. Constructionists' computers can assist students to concretise abstract ideas. Computer-based constructions can help students to assimilate and accommodate new knowledge where necessary (Swan, 2005). To sum up, there is no one constructivist theory of knowledge construction and students can construct their knowledge through their active involvement in the processes of knowledge construction and social interactions.

2.5 Concept of Academic Performance

The impacts of poor academic performance in Ghana have been of much concern to all educational stakeholders. The impact is that it has led to a fallen standard of education in the central region and Ghana as a whole. Students' academic performance is an objective score of attainment after a specified instructional program. Academic performance is seen as the knowledge attained or skills shown in the school subject. To indicate such achievement, test scores or marks are assigned by the teachers. It is the institutional evaluation of the classroom work based on the grades awarded.

Academic performance as a variable in students' learning has been an area of concern in present-day research. Busari (as cited in Dibal, Danjuma & Musa, 2022) defined academic performance as the exhibition of knowledge acquired or skills developed by students in school subjects. It is the degree of performance in the subject as exhibited by a student. Academic performance is the exhibition of knowledge attained or skills developed by students in the school subject usually designed by test scores or by marks assigned by teachers which can be low or high. Academic performance means how well one does in school. Poor grades are considered bad academic performance.

According to Cambridge University Report (2003), academic performance is usually described in terms of examination scores. Academic performance refers to what skills the student has learned and is usually measured through assessments like achievement tests, performance assessments and portfolio assessments. The assessment provides information on the anecdotal report of the student`s academic performance over a given period. Academic performance, which is measured by the examination results is one of the main objectives of the school. Academic performance involves three concepts; the ability to study, retain and recall facts, being able to study effectively and see how facts fit together and form larger patterns of knowledge and being able to think for yourself about facts. Third, to be able to communicate (Oakley & Coulson, 2008).

Adediwura and Tayo (Kenni, 2021) asserted that academic performance is generally referred to how well a pupil is accomplishing his or her tasks and studies but there are quite several factors that determine the level and quality of pupils` academic performance. This no doubt supports the view of Nicholas (2010), that the most current information on improving academic performance shows that there are three conditional influences linked to levels of academic performance among school pupils.

These influences according to the information include:

- High- quality parenting (the degree to which a young star is provided with an enriched, warm and responsive learning and home environment)
- High-quality child-care environments (stimulating activity and nurturing as reflected in high-quality parenting)
- High-quality first-grade classrooms (with a focus on literacy instruction, evaluative feedback, instructional conversation, and encouraging child responsibilities).

Lavin (2001), gives an objective definition of the term academic performance as traditionally used, the term academic performance refers to some method of stating or expressing a student's academic rank. Generally, this is a grade for a particular subject area or an average for all subjects expressed on a 0-to-100 or other quantitative scale. Bello (2006) stated that examination is the most viable instrument to measure students' academic performance. Oloyede (as cited in Jamiu, Ajidagba & Bolaji, 2021) opined that the outcome of the examination results will determine who gets promoted to the next class or otherwise. According to Abdul (as cited in Jan & Anwar, 2019), academic performance refers to the level of achievement displayed by students in terms of their grade point average across subjects offered in their year-end examinations.

In the same vein, Oloyede (as cited in Jamiu, Ajidagba & Bolaji, 2021) asserted that students' academic performance is the main focus of the overall educational performance. Academic performance is referred to as educational outcome. It is a yardstick used to determine how far a student has mastered a subject of study within a given period. Academic performance is a viable tool that can be used to determine and predict the standard of any educational system in Nigeria in terms of its efficiency and effectiveness. It portrays the quality of education offered in Ghana.

2.6 Measurement of academic performance

Determining academic performance serves as a source of motivation for students` learning. Students are encouraged to learn more seriously when they know that their learning will be evaluated and when they realize that their efforts and performances are being recognized. According to Lehman (2012), evaluation is the systematic process of determining the extent to which instructional objectives are achieved by students. Consequently, examination results and the teacher`s judgment are used to categorize or classify students. Irreversibly decisions are made regarding the students` worth and their future in the educational system. By this system of categorizing students, some are made to feel that they are deficient, performing low academically while others feel that they are good and desirable academically. This labelling of individuals may likely have some unfavourable influence on a person's self-concept.

This is basically what teachers do when they set tests or give assignments. This is the main job of examination bodies like the WAEC etc. Yusuf (2012), described evaluation as the collection and use of information as a basis for rational decision-making on the subject topics which need to be improved, or modified. It is a quality control exercise to ensure that resources are used maximally. The process will indeed yield information regarding the worthiness, appropriateness and validity of something for which a reliable measurement or assessment has been made.

However, various assessment or measurement tools and techniques may be used in evaluating or determining the teaching-learning process as well as the outcomes associated with it. Yusuf (2012), has identified the following instruments to be used in evaluating the teaching-learning process:

1. Test
2. Observation
3. Project
4. Questionnaire
5. Interview
6. Checklist
7. Sociometric technique or sociometry.
8. Rating scales.

Alabi et al. (2011), asserted that test is an important aspect of the educational process. It is the stage at which the students` knowledge, skill, ability and competencies are assessed and judgment is made about such performance. The outcomes of such judgment are used in diagnosing as well as placement of students. Scott (2011) stated that measuring academic performance can occur at multiple levels and serves multiple purposes. For example, classroom teachers often conduct formative and summative tests to evaluate students` mastery of course content and provide grades for students and parents. States tests are designed primarily to measure progress at the school and school level.

Megan (2011), suggested that standardized observational assessment can guide teachers and administrators in promoting effective teaching and learning, enhancing students' social and academic development as well as assessing their level of academic outcomes. Centre for American Progress (CAP) advanced that students` performance can be measured through administering achievement tests, analyzing stated testing results, using informal surveys to measure academic achievement and looking at grade reports.

Accurately measuring academic performance is an important part of planning for a child‘s education. However, no one source of information should be used to assess academic performance. A student may demonstrate knowledge of one instrument and not of another. Using good strategies to assess academic performance from multiple sources will ensure good information and the best possible educational planning.

The academic performance of students can also be measured in the following ways:

a. Administer a standardized achievement test.

A standardized test has to be given by someone who meets the qualifications required in the testing manual. Usually, that is a person who has coursework in administering that type of assessment. Standardized achievement tests compare the students being tested with the average student of the same age in a sample of students across the country. The advantage of these types of standardized tests is that they are well-researched and usually have pretty good validity and reliability. The disadvantage is that they do not tell where that child is at given what they have been taught in their classroom in their school district.

b. Analyze test results.

Each country chooses its standardized test to measure achievement and each defines its level of proficiency on that test. However, a student could have guessed well on the test or they could have had a bad day on the day of the test. This is one good way of telling what a student has learned but it should be considered along with other sources of information (Lavin, 2001).

c. Use informal surveys to measure academic performance.

Teacher surveys based on what has been taught in the classroom can be a good indicator of academic achievement. These are sometimes included in textbooks or they can easily be made up. They are a good tool to use to see what has been learned, what has been retained over time, and what has not been mastered and needs to be taught again.

d. Look at grade reports.

Grades are one tool to use to measure academic performance. They are a great indicator of academic success and short-term learning. However, grades do not necessarily measure long–term learning or mastery. For example, some students may do well on tests because they can memorize information and relate it at test time. However, it may be questionable if it was actual learning if they forget it right after the test and cannot demonstrate that knowledge at a later time. Grades are partially based on short-term knowledge that comes from weekly tests and homework, and only part of the grades is more long-term knowledge (Lavin, 2001).

In educational institutions, success is measured by academic performance or how well a student meets standards set out by the local or central government and the institution itself. Academic performance is what you have shown you can do in a certain subject. Ability is what you can do in an ideal circumstance. You can think of it as being internal and hidden until you show what you can do with your performance.

Academic achievement or (academic) performance is the outcome of education. It is the extent to which a student, teacher or institution has achieved their educational goals. The tracking of academic performance fulfils several purposes. Areas of achievement and failure in a student‘s academic career need to be evaluated to foster improvement and make full use of the learning process. Results provide a framework for talking about how students fare in school and a constant standard to which all students are held. Performance results also allow students to be ranked and sorted on a scale that is numerically obvious minimizing complaints by holding teachers and schools accountable for the components of every grade

2.7 Conceptual understanding of students in organic chemistry nomenclature

Students' conceptual understanding of organic chemistry has invaluable implications for chemistry teaching and learning in schools in Ghana and the entire world. Chemistry teachers will get insight from this review and plan for organic chemistry instruction considering students' prior knowledge, knowing areas where students have difficulties about the topic and engaging innovative teaching strategies that enable students to be active in the process of teaching and learning, interact with peers, enjoy practical experiences that may improve their discoveries. Students should not be treated as empty vessels or blank slates, on the contrary, learning activities should be related to their prior knowledge and interests and emphasize understandable material to enhance students' productive thinking. The use of the self-explanatory textbook (conceptual textbook) containing common students ‗conceptions in organic chemistry and their corresponding correct explanations can help students be aware of possible conceptions. Teachers need to have sufficient knowledge of the subject content that enables them to enhance students' conceptions and lead them to a brighter scientific future.

For the maximization of students' conceptions about organic chemistry, cooperative learning models such as the think-pair-share approach; Jigsaw approaches, reverse jigsaw, reciprocal peer teaching approach, student terms- achievement divisions (STAD), think-aloud pair problem-solving approach (TAPPSA); group grid approach; group writing assignment approach, base group learning, numbered head together and many other different innovative teaching strategies are recommended to apply in organic chemistry instruction.

Concepts, as defined by Lakpini (as cited in Ubanwa, & Omwirhiren, 2016), are ideas, notions or thoughts which can be regarded as the emerging image of the mental process. It may be a product of some intuitive re-appraisal. It could be concrete, abstract or even blurred. Concepts entail the summary of the essential characteristics of a group of ideas. Basically, in science, there are instances where the ideas in the mind of individuals may be different from what is scientifically correct (Sani, 2010). What is of great concern about conceptions is that individuals continue to build knowledge on their current understanding which may have a positive impact on future learning.

Numerous studies have demonstrated that students acquire their scientific conceptions from various sources (Adesoji 2008; Sani, 2010). These sources consistently establish frameworks or accurate representations of scientific concepts. The sources include but are not limited to personal experiences (such as observation), peer interaction, media, language, symbolic representation, textbooks, laboratory works, and environment, among others (Adamu, 2011). Several researchers also revealed that students of closely related ages held similar conceptions that influence their understanding of more complex concepts (Lee, 2004; Gonen & Kocakaya, 2010).

Hwang (2004) found that not only do students of secondary schools have notions or thoughts in identifying whether a substance is an acid or a base, but their teachers do as well. Students' inclination to certain key concepts in chemistry is on the increase. Such concept includes hybridization, chain reaction, chemical equation, polymerization and even the nomenclature of organic compounds. Previous studies revealed that students have conceptions of chemistry. Some of the conceptual areas in which most studies have been conducted are chemical equilibrium (Erdemir, Li & Jin, 2005), acid-base (Şendur, Özbayrak, & Uyulgan, 2011), chemical bonding (Taylor, 2002; Ozmen, 2008; Smith & Nakhleh, 2011), nuclear chemistry (Nakiboglu & Tekin, 2006), atomic orbital and hybridization (Nakiboglu, 2003), buffer solution (Orgil & Sutherland, 2008), solutions and their components (Çalık & Ayas, 2005; Pinarbasi & Canpolat, 2003), colligative properties (Pinarbasi, Sozbir & Canpolat, 2009), inorganic chemistry (Adesoji 2008; Sani, 2010), organic chemistry (Childs & Sheehan, 2009) and electrochemistry (Huddle & White, 2000).

Prominent among the factors that have been identified to be responsible for these conceptions are a method of instruction, proper exposure to laboratory activities, organizational skills and adequate exposure to problem-solving procedures among others (Sani, 2010). It is acknowledged that learners actively select information and also construct it for them to learn meaningfully. All existing knowledge, including concepts and information processing strategies, play a vital role in shaping learning outcomes because they influence new stimuli and the subsequent generation of meaning. As learning is a personal construct there is the likelihood that some constructions will be erroneous and consequently may adversely affect subsequent learning. Identification of these misconceptions will be the first step in trying to look for a way to remedy them. It has been shown that if the right approach or method is used in teaching organic chemistry, the problem of misconception can be minimized (Heemsan, 2005; Bryan, 2007).

A student who has a partial understanding of a concept or misconception will likely resort to rote learning. In contrast, a student who properly understands the concept would approach the problem requiring a solution in his way and may be able to tackle most puzzles correctly. There is also a strong indication that lack of awareness of misconceptions by students in chemistry may be contributing factor to students�What poor academic performance in chemistry. Despite the several studies by various science educators, there is as yet little or no study in central region Ghana aimed at establishing the major conception in the learning of organic chemistry.

A Concept can be observed in two ways in its abstract nature or concrete one. The real concepts are enhanced by students' experiences, whereas abstract concepts are considerably challenging for students to perceive (Uce & Ceyhan, 2019). These similar concepts are described by various researchers and some of them include conceptions, personal constructs, multiple private versions of science, developing conceptions, and interpretation of facts (Aufschnaiter & Rogge, 2010).

Conception was held by several pre-service natural sciences educators about geometric isomers (Sendur et al., 2011). It is from the use of 1,2- dichloroethene as an example of geometric isomers that scholars assume that only alkene combinations comprising two halogen bonds on C=C bonds have geometric isomers (Sharma & Decicco, 2018).

New concepts can be easy to learn if misconceptions are corrected among students, some of them can be detached simply although most of them are strongly held and regularly not affected by regular classroom instruction since these are something learners trust (Belachew, Barke, & Yitbarek, 2018). Students usually have difficulty in the learning of organic chemistry due to no algorithms' problem-solving of this topic as it has an extensive new vocabulary and requires three-dimensional thinking (Wu, Krajcit, & Soloway, 2001). Among the major conceptions of organic chemistry for students is the understanding of the three-dimensional nature of molecules which they have extreme difficulty converting between the two-dimensional drawings used in textbooks and on boards to represent molecules and their three-dimensional structures without this understanding to continue the course, students have to pretend they understand the three-dimensional structures (Bateman, Booth, Sirochman, & Richardson, 2002).

The diagnosis of students‘ conceptions can be done by identifying and addressing them through questioning and listening. These approaches comprise various forms of real-type feedback which can stimulate students‘ participation while learning (Patil, Chavan, & Khandagale, 2019).

Another approach is illustrated by the method known as Just-in-Time teaching as an educational approach that uses feedback from the work that students do at home, in preparation for the classroom meeting and activities (Killi & Morrison,2015). These goals are meant to enhance learning in the classroom, develop students‘ motivation and stimulate their previous preparation for class and permit the teacher to fine-tune the classroom accomplishments to best meet the needs of students (Cakir, 2008). In such a situation, teachers respond to various questions before class and the teacher uses the given answers from students to familiarize his or her teaching with their conceptions and to what they already know positively. The way of interviewing students to produce the items that make up a concept inventory or other forms of diagnostic apparatus is also a research-intensive approach that may be used (Stojanovska & Petrusevski, 2017). Concept inventories can also help identify problematic ideas that can hinder active instruction (Bryan, 2007). The use of micro kits in creating small-scale organic chemistry experiments has been known to improve students‘ conceptions in most south-east Asian countries including Thailand, Japan, Taiwan, and Indonesia (Supasorn, 2015; Zakaria, Latip, & Tantayanon, 2012).

In Ghana, (Hanson & Sakyi-Hagan, 2019; Hanson, 2014), Ethiopia (Gebrekdian, Annette, & Lise, 2014) and Tanzania (Mafuniko, 2008), when this strategy was introduced to chemistry students in Ghana, it was found to be a tool to enhance students' understanding and academic performance (Hanson, 2014). Students who applied them in practical experiences made conceptual improvements as they surmount their challenges in principles that directed the study of organic chemistry (Hanson, 2017). In this manner, they are exposed to a kind of concrete experience as they observed the causes and effects of phenomena in different variables (Darling-Hammond, Flook, Cook- Harvery, & Osher, 2019). These concrete experiences enhanced their concept formation and subsequently academic performance.

The deep foundation of accurate knowledge is where learners use observation, reasoning, and imagination about scientific phenomena by learning the ways of organizing knowledge within a conceptual context (Duran & Duran, 2004).

Furthermore, the acknowledgement and revision of the conceptions of students involve innovative teaching strategies rather than passively learning approaches. A common method of instruction includes meta-cognition which is to boost the students' thinking about techniques for addressing a particular problem (Fisher, 2006). This technique necessitates students to express and defend their understanding. The recognition of the authenticities of the current classroom requires the application of innovative teaching methods that provide the active participation of students and incorporate their metacognition and critical thinking then the creation of a deep foundation of factual knowledge which enables students organizing the knowledge within a conceptual structure based on the experienced events (Cakir, 2008; Canelas, Hill, & Novicki, 2017). Teachers monitor the concepts changing of the students through the evaluation techniques as the teaching proceeds.

Through different approaches that apply formative assessment in education, educators find ways to help students redirect scientific misconceptions and assist them to reconstruct their conceptual framework (Dunlosky, Rawson, Marsk, Nathan, & Willingham, 2013). However, deciding to create manners to help learners overcome their misunderstandings one might try employing different methods including the application of innovative teaching methods that allow learners to actively participate in the learning process and to discover more (Uce & Ceyhan, 2019).

The process of teaching and learning organic chemistry could be structured by enabling students to overcome challenges for them to be prepared for the world of tomorrow offering them information and helpful examples which they are familiar with showing them the cognitive processes that lead to conceptual generalizations and algorithms (Opara, 2013). Organic chemistry teachers should try to include conceptual questions assessing students' understanding of the fundamental notions in the subject instead of just setting questions which require only mostly recall and rote learning. The way a student processes the learned information and applies it goes hand in hand with his or her learning style (Woldeamanuel, Atagana, & Engida, 2014).

Evaluation of students' abilities is assumed to be one of the most widespread yet controversial exports both in academics and the real world (Deary, Strand, Smith & Fernandes, 2006). The evaluation is mostly intended to provide an objective measure of individual differences based on cognitive aspects that undoubtedly exist within society. The outcome of such evaluation has proven to produce both practical and theoretical implications.

Most importantly, it would justify the rationale for the use of such instruments as a selection guide in a wide range of fields including educational and occupational fora. Empirical data shows that an attempt to predict individual differences in educational outcomes was the main reason for the first broad test of cognitive ability (Zenderland, 1998) and the discovery of general intelligence involved in part using individual differences in school examination scores (Spearman, 1904). Alongside occupational outcomes (Schmidt & Hunter, 1998), educational outcomes are the major target for the predictive validity of cognitive ability tests. Generally, there is a broad agreement that a moderate to strong correlation exists between cognitive ability and educational achievement. Previously, Jencks (1979) detailed an account of eight samples from six longitudinal studies and reported correlations ranging from 0.40 to 0.63 between cognitive test scores and the amount of education obtained.

Recently, overviews provided by various researchers indicate similar conclusions (Bartels, Rietveld, Van Vaal, & Boomsma, 2002; Grigorenko, Wenzel Geissler, Prince, Okatcha, Nokes, Kenny, & Sternberg, 2001). Mackintoshs‘ (1998) survey, for instance, reckoned that there is a correlation of 0.4 and 0.7 between IQ scores and school performance grades. Similarly, Deary et al. (2006), found a large contribution of general mental ability to educational achievement overall.

In chemistry, studies have shown that students‘ level of achievement is based on their mathematical and visual-spatial abilities. Relative to mathematical ability, Salau (2000) pointed out that there exists an impenetrable link between mathematics and other science subjects while Peters, Howard and Sharp (2012), insist that the mathematical ability of students is very important in the learning of chemistry especially in the present age of computer and information technology which uses a lot of mathematics.

Omilani and Nyinebi (2015), on their part, asserted that like any other school subject, chemistry requires the mental ability of the students to be able to cope with the learning of the subject. Their findings showed that mental ability made the highest contribution followed by mathematical ability. Findings by Ajewole, Oginni and Okedeyi (2006) showed that 36.2% of the total variance in the students' performance in chemistry is accounted for by the four student's aptitude indices. Among the indices, mental ability made the highest contribution followed by mathematical ability. This shows that the performance of students depends largely on the students' aptitude indices in chemistry. Visuospatial aptitude which entails three components, spatial visualization, spatial orientation and spatial relations (Barnea & Dori, 1999 as cited in Wu & Shah, 2004) has been strongly linked to obtaining academic mastery of several science disciplines.

For example, Siemankowski and MacKnight (1971) as cited in Wu and Shah (2004) found that science students, who were mostly physics majors possessed more highly developed visualization skills than non-science students. Pallrand and Seeber (1984) as cited in Wu and Shah (2004) investigated and found spatial aptitude in successful students of physics. In the same way, Lord (1985) as cited in Wu and Shah (2004) found similar results for biology students while Baker and Taliey (1972) as cited in Wu and Shah (2004), and Melntosh (1986), as cited in Wu and Shah (2004), made similar studies for chemistry students and found similar results. Therefore, researchers have come to agree that visuospatial ability is an important cognitive operation for success in science due to the correlation found between spatial ability and achievement in science.

Specifically, Delialioglu and Askar (1999), found that there is a significant correlation between mathematical skills and chemistry performance. Moreover, multiple regression analyses of MST and SAT scores with PAT scores yielded a significant contribution of mathematical skills and spatial ability to physics achievement. Accordingly, students' mathematical skills could explain about 21% of the variance in physics achievement when entered into a regression equation with spatial ability. Talanquer (2014), found that the main obstacles to developing spatial abilities in chemistry were insufficient understanding of the depth cues provided in two-dimensional representations and the inability to visualize the position of atoms after rotation. Thus, they advocated for the use of instruction methods such as DMI that guide students to visualize three-dimensional structures from their two-dimensional representations and encouraged the use of teaching aids that incorporate models, stereo-diagrams, mirrors, shadows and dynamic pictures that have been used in related remedial instruction programs and have proved to be useful in improving learner skills related to spatial ability.

Pribyl and Bodner (1987) as cited in Wu and Shah (2004) illustrated in their study revealed that students with high spatial scores perform significantly better on questions which require problem-solving skills, such as completing a reaction or outlining multi-step synthesis questions which require students to mentally manipulate two-dimensional representations of a molecule. Spatial ability was not significant, however, for questions which could be answered by rote memory or by the application of simple algorithms. Bodner and McMillan (1986) suggested a high correlation between spatial ability and performance in a general chemistry course for science and engineering majors. This correlation was seen not only on highly spatial tasks such as predicting the structures of ionic solids (r = 0.29) but also on tasks such as multiple-choice stoichiometry questions (r = 0.32) that do not involve spatial skills. According to Carter, Larussa and Bodner (1987) as cited in Wu and Shah (2004) scores on the spatial tests consistently contributed a small but significant amount to success on measures of performance in chemistry.

Empirical data exist that attest to the effect of DMI on students‘ mathematical and visual-spatial abilities thus overall abilities in chemistry. For instance, Morgil et al. (2005) worked together on the effect of digital media learning on computational attitudes, three-dimensional spatial visualization abilities, and learning styles of students in acids and bases. The findings showed that computational attitudes, three-dimensional spatial visualization abilities, and learning styles of the students did not affect their test scores. However, a 52% improvement was observed in the post-test results of the students of the experimental group and a 31% improvement was observed in the post-test result of the students of the control group. Thus, a significant difference was found favouring digital-assisted instruction signifying that the teaching strategy promotes more students‘ learning abilities. Similarly, Steffen, Gill, Gundersen and Nelson (1996) posited that when students construct and animate molecules they get a chance to see how a chemist or organic chemist thinks about structure. This helps bridge the gap between the traditional chalkboard drawings and more sophisticated visualization techniques scientists use.

Barnea and Dori (1999) found that students who were exposed to computerized molecular modelling (CMM) software in a study of its effect on high-school chemistry students' performance and gender differences performed better than those who were not in all three performance aspects. Their achievement scores were higher and though students' spatial ability improved in both groups, students from the experimental group scored higher implying that they gained better insight into the model concept than the control group and could explain more phenomena with the aid of a variety of models. An analysis of the findings for the average students in both groups indicated a unique and discernible improvement in all three spatial ability sub-tests – paper folding, card rotation and cube comparison with that of the experimental group being significantly higher. This was interpreted to imply that this group of learners gained better insight into the model concept and could explain more phenomena with the aid of a variety of models. It was thus concluded that

CMM helps in particular to improve the examined cognitive aspects of the average student more. This was attributed to a better understanding of chemical bonding and improved three- dimensional perception of molecular structure gained through the CMM experience of students in the experimental group. This improvement in their perception of various geometrical shapes and the relation between the molecular formula and geometric structure is in accord with the findings of Gabel and Bunce (1994).

Studying organic chemistry at the microscopic level (that is, nature and arrangement of molecules used to illustrate the characteristic properties of hydrocarbons and other compounds) and symbolic level (that is, representations of atoms, molecules, and compounds, such as chemical symbols, formulae, and structures) is arguably difficult for chemistry students (Ben-Zvi, Eylon, & Silberstein, 1986). The reason is that the microscopic and the symbolic levels of chemistry are abstract, and therefore learning chemistry for comprehension and analysis depends much more on the use of the sensory organs. Little wonder that chemistry students find it challenging in comprehending and analyzing molecular formulae, structural formulae and symbols. The concept of the IUPAC nomenclature of compounds is at the symbolic level and could be said to be difficult for most students.

Chemistry students' comprehension is obstructed by the superficial features of representations (Kozma & Russell, 1997). Most chemistry students see formulae of organic compounds (for example, CH_3OH or C_2H_6O) as a combination of alphanumeric rather than molecular formulas (Wu et al., 2001). The difficulty of some students in understanding organic representations is also seen as an area where most students are unable to make translations among formulae (Keig & Rubba, 1993).

According to Keig and Rubba (1993), for learning to be meaningful and reasonable to a student, it has to be constructed or premised on an important set of concepts that he or she is used to. This means that an attempt must be made to link chemical phenomena which are abstract to their representations to make them understandable. Kavanaugh and Moomaw (1981) posited chemistry students presume chemistry to be a difficult subject. This in effect has resulted in many students having difficulties in understanding scientific concepts in chemistry.

Kelly (as cited in Jones, 1991) revealed that most students drop out of the physical sciences of which chemistry is included to the biological sciences and other fields of academics as such students perceive them to be difficult. The findings of Baah (2009) revealed that students have difficulty in writing structural formulae of organic compounds from the IUPAC names. Bello (2006) has revealed that the difficulties of students in solving stoichiometric problems are responsible for their inability to write chemical formulae as required by the IUPAC system. In naming some organic compounds (molecular formulae) using the IUPAC system, Baah (2009) found out that chemistry students are faced with some difficulties due to their inability to correctly write the names of some hydrocarbons and organic compounds.

These difficulties, according to Baah (2009), are a result of the chemistry students‘ inability to locate the central carbon chains of some given structural or molecular formulae. These difficulties are a result of the chemistry students‘ inability to write the correct names of some hydrocarbons and to deduce the Carbon and Hydrogen numbers of the straight carbon chain of some structural formulae as a result of their lack of knowledge about the concept (Baah, 2009). According to Wu, Krajcik, and Soloway (2001), many students learning chemistry have challenges learning symbolic and molecular representations. They, therefore, conducted a study with 51 eleventh-grade students of a small public high school in a midsize university town in the Midwest to investigate how chemistry students develop and understand chemical representations using a computer-based visualizing tool for 6 weeks. To them, the computer-based visualizing tool was referred to as eChem.

One of the chemical concepts studied within the 6 weeks by Wu et al. (2001) was IUPAC nomenclature of organic compounds such as hydrocarbons. Wu et al. (2001) pointed out that with the help of eChem, chemistry students were able to apply modern rules of IUPAC nomenclature to draw structures of some given organic compounds. For instance, the students were made to name and draw the structure of a six-carbon atom compound with a side group. The understanding of the high school chemistry students used in the study was said to have improved reasonably resulting in high performance on IUPAC nomenclature of organic compounds. This is based on the fact that there was a statistical significant difference between the means of pre-test (N = 71, M = 31.1) and post-test (N = 71, M = 59.5) results after they had been subjected to a paired two-sample t-test analysis (SD 2.5, $t(70) = 13.9$ p 0.001) with an effect size of 2.68 (Wu et al., 2001).

2.8 Concept of dual-coding Learning

Dual-coding theory (DCT) proposed by Allan Paivio (2013) postulates that nonverbal and verbal information is stored separately in long-term memory. According to Paivio (2013), dual-coding theory suggests that visual and verbal information act as two distinctive systems.

DCT identifies three types of information processing:

- Representational: the direct activation of verbal or non-verbal representations.
- Referential: the activation of the verbal system by the nonverbal system or vice versa.
- Associative processing: the activation of representations within the same verbal or nonverbal system. Therefore, a given task may require any or all of the three kinds of processing outlined above.

According to Paivio, verbal system units are called logogens; these units contain information that underlies one's use of the word. Non-verbal system units are called imagens. Imagens contain information that generates mental images such as natural objects, holistic parts of objects, and natural grouping of objects. Imagens operate synchronously or in parallel, thus, all parts of an image are available at once. Logogens operate sequentially; words come one at a time in a syntactically appropriate sequence in a sentence.

The two codes may overlap in the processing of information but greater emphasis is on one or the other. The verbal and non-verbal systems are further divided into subsystems that process information from different modalities. Many experiments reported by Paivio and others support the importance of imagery in cognitive operations. Paivio observed that participants when shown a rapid sequence of pictures as well as a rapid sequence of words and later asked to recall the words and pictures, in any order, were better at recalling images. Participants, however, more readily recalled the sequential order of the words, rather than the sequence of pictures. These results supported Paivio's hypothesis that verbal information is processed differently from visual information and that verbal information was superior to visual information when sequential order was also required for the memory task (Paivio, 2013).

However, as a principle recall recognition is enhanced by presenting information in both visual and verbal. According to Pylyshyn (2003), many researchers have agreed that only words and images are used in mental representation. In a similar vein, evidence shows that memory for some verbal information is enhanced if a relevant visual is also presented or if the student can imagine a visual image to go with the verbal information. Likewise, visual information can often be enhanced when paired with relevant verbal information, whether real-world or imagined (Anderson & Bower, 1974). According to Mayer (2014), one implication of Paivio‘s theory is that only using text will be less effective than using text and a relevant image if one intends to learn a scientific system such as how the lungs work.

Another implication is that cognitive load demands decrease if we use both channels instead of overloading one channel (typically the visual one). Paivio‘s work has implications in many areas including literacy, visual mnemonics, idea generation, as well as the development of educational materials among others. It equally has implications for cognitive sciences and computational cognitive modelling (Anderson & Dexter, 2005; Sun, 2002). Dual-coding theory has also been applied to many cognitive phenomena including: mnemonics, problem-solving, concept learning and language. This theory has been applied to the use of digital and multimedia presentations. Digital and multimedia presentations require both spatial and verbal working memory, individuals dually code information presented and are more likely to recall the information when tested at a later date (Brunyé, Taylor & Rapp, 2008).

Similarly, Proponents of using technological advances to aid education use the dual coding theory to promote their views. They claim that dual coding lends justification to using digital media applications in the classroom. Such media applications make use of text, image, audio and video at the same time while conventional teaching methods remain focused on the verbal presentation of material.

Digital media learning occurs when students use information presented in two or more formats such as virtually presented and animation-presented narration-to construct knowledge (Mayer & Sims, 1994). Mayer (2001) adapted the model to explain the connection between verbal and visual modes of mental representation. This study is related to this theory as it investigates the effect of digital media (use of multiple media such as words, pictures, audio, video, internet, e.t.c) on academic performance.

As the dual-coding theory suggests, the digital media instructional strategies developed for this study are multi-sensory that is, it applies to a different sense of the learners (verbal and non-verbal) as it contains video, audio, internet, text files, pictures, etc. unlike the conventional method of teaching that applies to the verbal presentation of materials alone. Digital media in science teaching and learning refer to presentations that contain both words and graphics (Kari Jabbour, 2012). According to Bharatka (2006), many researches confirmed that learners obtain more knowledge from words and graphics than from words alone in teaching (Mayer and Anderson, 1992; Clark & Lyons, 2010), and recommended the use of digital media for instructional delivery. He identified four important characteristics of digital media:

i. systems are computer controlled
ii. systems are integrated
iii. the information content must be represented digitally
iv. The interface to the final presentation of media.

Although using printed or spoken words is the primary way for conveying information as words are simple, easy and cheap to utilize (Kari Jabbour, 2012), however digital media presentations can encourage learners to engage in active learning by representing the materials in words and pictures and by mentally making connections between the pictorial and verbal representations.

According to Mayer and Mereno (2002), teaching materials with written words and pictures allow the learners to produce multiple representations which contribute to long-term memory and pictures could promote learning and understanding better than written words. Digital media packages not only bring more abundant visual and hearing enjoyment for people but also increase the interest in learning and learning effect. As a result, the use of digital media could present a lot of effects on the learners that the traditional teaching methods could not, Chen and Chang (2011). Digital media packages are useful resources for teaching and learning these include practice programs, video tutorials, educational software and Microsoft Powerpoint for making lesson presentations using digital projectors (Bharatka, 2006). He also opined that meaningful learning occurs when the learner interacts with the various modes of presentation. Similarly, Babajide (2015) identified different types of digital media, some of which include computer hardware, computer software, slides, overhead projectors, opaque projectors, videos and still and motion pictures among others.

The evolution of digital media has made it very possible for learners to become more involved in their work. Digital media technologies can help students or learners create multiple applications as part of their project requirements. This would also make them active participants in their learning process, instead of just being passive learners of the educational content. Digital media educational systems are rapidly growing in popularity because they enable us to provide a variety of presentation modes in support of the learning process (Anderson, 2020; Heller, 2001).

Gulzar (2014) opined that digital media is changing the way we communicate with each other. The way we send and receive messages is more effectively done and better comprehended. The inclusion of media elements reinforces the message and the delivery which leads to a better learning rate. Zheng and Zhou (2017) opined that with the advent of digital media technology in the classrooms, teachers can equip themselves with these technological skills and become better communicators of their content materials and thus enabling the students to learn more productively.

Tway (1995) posited that digital media offers an excellent alternative to traditional teaching by allowing students to explore and learn at different paces every student has the opportunity to learn at his or her full potential. Thus, with the combination of digital media technology and educational content materials, the final interactive content can be delivered in various ways and made available for the different teaching and learning modes such as teacher-centric, student-centric and mixed modes (Neo and Neo, 2004).

When a computer is connected to a projector, it allows a whole class delivery of information, allows equal access to information and also enables the use of multimedia files such as text, pictures, sound and video files to enhance understanding of ideas and concepts. NOUN (2006) opined that in addition to knowing why digital media technology is used in the classroom; it is also important that you know there are different ways digital media technology can be used in the classroom, it all depends on the learning intention or behavioural objectives of the lesson. The following shows the various ways in which files could be selected as described by NOUN:

- Text files – this could be in the form of explanations, descriptions, opinions, reports, instructional, fictional etc. They could also be used to support other lessons in the classroom.
- Sound files – these are pre-recorded sound snippets; which could be in the form of speeches, songs, teaching especially in languages etc.
- Animation files – these types of files are very good for illustrations. They could be in the form of moving pictures with text and sometimes with sound.

A study by Ubogu (2007) supports the view that digital media resources facilitate access to all human knowledge, anytime, and anywhere in a friendly, multi-modal, efficient and effective way, by overcoming barriers of distance, language and culture. It is important to say that the use of digital media technology has great significance in colleges, universities and research institutions in Western countries. Nothing could replace a well-equipped audio-visual aid using a good teacher (Darma, Karma & Santiana, 2021).

2.9 WAEC Chief Examiners' Reports on IUPAC Nomenclature of Organic Compounds

The WAEC chief examiner of chemistry at the senior high school (SHS) level in Ghana has lamented on several occasions about the weakness of most students in IUPAC nomenclature of organic compounds (WAEC, 2000; 2001; 2002; 2003; 2004; 2005; 2006; 2007; 2010). In 2001, the Chief Examiner's Report showed that many candidates attempted Question 2 but some candidates could not give the IUPAC names of the compounds. In 2002, according to the chief examiners' report, candidates showed weakness in IUPAC naming of simple organic compounds. For example, candidates could not name C_6H_5Cl as chlorobenzene. In 2004, the chief examiner's report indicated that candidates referred to $CH_3─CH(NH_2)─COOH$ as 2-amidepropanoic acid instead of 2-aminopropanoic acid.

In 2005 and 2010, according to the chief examiner's reports, candidates could not correctly write the IUPAC names of the structural formulae of some given organic compounds. For example, in 2005, candidates could not write the correct IUPAC names of $HCOOCH_3$, $CH_3CHOHCH_2OH$ and C_6H_5COOH as methyl methanoate, propane-1,2-diol and benzoic acid respectively. In 2006, the chief examiner's report pointed out that candidates could not give the correct IUPAC names and structures of some organic compounds. From the above revelations of the chief examiners' reports, it is clear that Ghanaian students have been facing a challenge with the IUPAC naming of organic compounds in their chemistry final examinations conducted by WAEC.

2.10 Instructional content

Chemistry is the study of matter and its interactions with other matter and energy. It is one of the most essential subjects that permeate every scope of activity including Agriculture, Biotechnology, Engineering, Environment and Medicine. Furthermore, chemistry has contributed enormously to improving the quality and comfort of human life in the present-day world (Memije-Cruz, 2010). It is, therefore, vital that the teaching of chemistry be done in such a manner to lay a strong foundation on which future careers are built and even make a career out of it. Basic chemistry is significant therefore one can decide to undertake any of the Sciences because all of the Sciences involve matter and the interactions between types of matter.

Therefore, every chemistry teacher aims to aid students to understand scientific concepts and chemical phenomena (Barak, 2007). One way to achieve this aim is to engage students in information processing and problem-solving activities that emphasise real-world experience, and daily-life Chemistry (Engestrom, 2014). Students who wish to become chemists, doctors, geologists, nurses, nutritionists, pharmacists, etc. should study chemistry. Chemistry-related jobs are many and high-paying therefore one might want to make a career in Chemistry. The importance of Chemistry will not be diminished over time so it will remain a promising career path. However, in the Ghanaian setting where this research was carried out, Chemistry as a subject is not taught at the Lower School level.

According to Cigrik (2009), using digital media tools in teaching has led to improved quality content delivery which in turn leads to better student performance. The most significant factor in a country‘s success achieved in its curriculum objectives is through the use of information, knowledge, and technology. Papert (2003) saw the computer as the most prominent tool for students to use to create their own learning experience and to introduce them to the process of active experimentation. Kozma and Russell (2003) and Clarke (2002) reviewed research literature related to learning with different media, such as books, television and computer and concluded that the computer can be a powerful tool to aid learning because the books, television and computer can create a dynamic symbolic representation of non-concrete, formal constructs that are frequently missing in the mental frame of a novice.

2.11 Pedagogical Content Knowledge in Organic Chemistry

Many strategies are available to the chemistry teacher. The use of a particular strategy may depend further on factors such as skills, cost of production and available materials. Since the work of the chemistry researcher is purposely for publication in journals the strategy, he chooses for his experiments may be determined by the cost of production. An experiment to be illustrated in small quantities for a thesis or distribution in a classroom may be photocopied. Human beings have a "natural eagerness to learn" and they are responsible for and at the Centre of the learning process (person-centred learning). Digital media instruction is possible only because individuals who signed up for it are self-driven and eager to learn despite their location of learning institutions.

The role of the teacher is to act as a facilitator. No amount of effort on the part of the teacher can guarantee success unless the learner has a desire and predisposition to learn. Learning involves changing one's self-concept. Such changes may involve discovering one's strengths or weaknesses. Pedagogy-based research has proven that acquiring and developing proficiency in chemistry transcends beyond knowing and recalling facts. It has been posited that for students, demonstration of the similarities and contrast between facts and concepts within the conceptual frameworks is important for mastery and even though good instruction can facilitate this process, developing conceptual understanding of science is difficult and takes time (Siddiqui & Khatoon, 2013).

Furthermore, research has shown that modern modes of instruction in sciences that carefully integrate scientific processes with other forms of instruction have the potential to boost interest, strengthen scientific reasoning, logic and increase mastery of the concepts to be taught. One of the new teaching strategy in this era is digital media learning with its various modes such as computer graphics that can support the new, inquiry-base strategy to science education, providing field learning experiences that overcome experiential and logistical barriers to students' concrete experience (Linn, et al., 2010).The integration of digital media in education is based on its potential to strengthen the educational system therefore better prepare students for the information age and accelerate efforts of national curriculum development (Albirin 2006). It is credited with having the ability to promote active learning in a wide variety of disciplines from literature to the social sciences, etc. (Gonzalez & Birch, 2000). Research has also shown that the use of digital and computer-supported programs can greatly improve performance (Cotton 1991; Ku, Harter, Liu, Yang, Cheng, 2005).

ImpaCT2 (2001) showed likewise that the use of digital media in classroom instruction impacts positively attitude, interest, interaction and problem-solving skills enabling students to learn independently. The study showed that the performance of students in schools where teachers used digital tools for classroom instruction was higher. This assertion is buttressed by Funkhouser (1993) who in a comparative study posited that students who were taught by visual-supporting problem-solving software scored significantly higher on achievement tests than groups of students who were taught conventionally. Their problem-solving abilities also improved. Guhlin (1996) made a similar observation and thus advised teachers to use technology such as computer graphics and media for experiential learning and to aid their students develop metacognition. Jonassen (2000), described digital media as an ICT tool that supports learning by allowing students to construct knowledge, explore and assess information with other students. The researcher asserts that digital media tools are advantageous in the sense that they teach students more effectively, keeping the students‘ attention more focused on the subject matter.

Osborne and Collins (2000) also posited that new technologies can be used to enhance student interest, facilitate better critical thinking and develop reflective observation with data. Additionally, digital media is presumed to provide an improved alternative to overcrowded classrooms (Abdel- Wahab, 2008). They unanimously maintained that the use of internet support medium to raise performance. All science subjects apply digital media tools in collecting data, cooperating and interacting with resources such as images and videos to encourage communication resulting in enhanced student performance in the respective subjects. (Bhagwan, 2005) From their research findings, the researchers concluded that integrating digital media learning tools in the teaching of sciences can lead to increased students‘ learning competencies and communication.

The advantages of integration and use of digital media learning tools in classroom instruction of chemistry are ;it can be instructed to execute a particular instructional strategy effectively and efficiently and therefore learner-teacher interactions ,study and feedback is much greater than is possible in conventional teaching situation., complexity of the teaching-learning process is such that only with the help of the data processing capabilities of a computer can we hope to improve the teaching-learning process from its primitive state of development (Akcay, Durmaz, Tuysuz & Feyzioglu, 2006). Integration and use of digital media tools in chemistry class have been linked with enhanced visual representations of chemistry concepts resulting in the positive effects of its use. Among the proponents of this school of thought, Bhukuvhani, Zezekwa and Sunzuma (2011) and Yushau, Mji and Wessels (2003) maintain that with digital media tools, concepts which could otherwise be difficult to comprehend without the tools can be visualized by the learners. Digital media learning tools provide clearer illustrations to students than those a teacher can make. Research reported that students found visual images of organic structures on a computer screen to be more instrumental to their understanding as compared to diagrams in books.

The visual images are reported to transcend beyond verbal and graphics in helping students comprehend concepts, that appear difficult when oral instructional methods are used. Consequently, Henriques (2002) as well as Dori and Barak (2000) as reported in Kargiban and Siraj (2009), posited that the use of digital media learning tools improves instruction in chemistry and strengthens the learning environment leading to improved students performance, This assertion is supported by Akcay, Feyzioglu and Tuysuz (2003) and Ezeudu and Ezinwanne (2013). Similarly, Bhukuvhani et al. (2011) observe that the use of digital media in the instruction of chemistry leads to results superior to those achieved when conventional methods of instruction are used.

According to researchers, instruction in chemistry should be innovative in conjunction with practical experiments. They argue that it is more efficient and effective for digital media tools to be used to run learning activities even in practical experiments in chemistry. This proposition is supported by Aksela (2005) who cited that use of digital media tools to learn enhances a rich learning environment and can be used to engage students in higher-order skills learning.

Garanga et al. (2012) specifically observed that digital media learning impacts students�s performance in bonding and structure positively. This is supported by Frailich, Kesner and Hofstein (2007) who in an investigation of the influence of integrating a website into chemistry teaching of chemical bonding found that the tool enhanced learners�s comprehension of chemistry concepts and increased their awareness of the relevance of chemistry to daily life. Also, Akçay et al. (2006) studied the effect of digital media learning on the performance and behaviour of university students in analytical chemistry found that the performance of the experimental groups was significantly higher than the control group. Other areas in which the efficiency of digital media learning has been tried and proven with similar results include electrochemistry (Hailegebreal, 2012); acids and bases (Dasdemir, Doymus, Simsek & Karaçöp, 2008; Ozmen, 2008). In all these studies, the post-test scores of the experimental group showed statistically significant differences as compared to the control group indicating that integration of DMI enhanced students�s understanding of chemical concepts and increased their motivation during the lessons. Similarly, Nduati (2015) found a statistically significant mean difference in the achievement of students taught carbon and its compounds using CAL relative to those taught through conventional methods.

Computer software can be utilized in organic chemistry education to enhance students' mastery of nomenclature, structural and molecular formulae of organic hydrocarbons, and other compounds, thereby leading to improved learning outcomes. Computer graphics can also be used to demonstrate molecular shapes, isomerism etc. (Barnea & Dori, 1999; Bhukuvhani et al.,2011). The researchers specifically argue that use of DMI supported tools in instruction of chemistry particularly in topics such as organic chemistry could enhance students' spatial abilities in the subject and improve their attitude towards the subject. However, empirical data to specifically prove the validity of such assumptions for teaching organic chemistry are not readily available in Ghana. Data in advanced and less advanced jurisdictions have shown that Governments through public-private partnerships with individuals and institutions have strived to support and strengthen the integration of digital media tools in classroom teaching by providing educational institutions within their countries with requisite hardware and software materials.

According to Plante and Beattie (2004), during their study conducted in the 2003/04 school year, nearly all Canadian schools had implemented the use of desktop computers or laptops for educational purposes. Similarly, Condie, Munro, Seagraves and Kenesson (2007) found that all schools in England had embraced the modern mode with each school having achieved or exceeded the projected target for the computer-to-student ratio. Similar scenarios are depicted for Slovene schools as well as Indian schools (Sorgo, Verckovnik & Kocijancic, 2010). For American schools, the classroom technology revolution seemed to have picked up pace as far back as the early 1980s and since then individual states have taken the initiative to provide ICT infrastructure to schools within their jurisdiction (Cheema & Zhang, 2013; Richardson, Finholt- Daniel, Sales & Flora, 2012).

In Africa, from 2010 through 2012, private schools were absolutely (100%) and almost all public (97. 9%) schools in Morocco and Tunisia were reported to have access to computer and ICT accessories (Richardson et al., 2012). Nigeria launched an ICT- driven project known as School Net to equip and furnish all schools in Nigeria with computers and related communication technology tools for teaching and learning. Research data have also shown that East and South African countries and their government agencies have not been left behind and have endeavoured to revolutionize their classroom pedagogical strategy through the adoption, integration and use of digital media (Kituyi & Tusubira 2013; Richardson et al, 2012; Sife & Bernard, 2013) The government in collaboration with a variety of stakeholders have made strides to make digital media tools including computer, internet connectivity and other peripherals available to schools.

Some of the prominent educational stakeholders in equipping public schools with ICT hardware and software include the Ghana education trust fund (Getfund), the Government of Ghana (GoG) Wi-F for all secondary schools, Old Students Association (OSA) (Ayere, Odera & Agak, 2010; Keengwe, Onchwari & Wachira, 2008; Wambui & Barasa, 2007). Through the goodwill and efforts of these well-meaning individuals and organizations, several secondary schools have been adequately furnished with ICT infrastructure for integration. Individual schools through the efforts of their Old Students‘ Association (OSA) have also endeavoured to equip themselves with ICT infrastructure in an attempt to modify their learning environment (Farrell, 2007). However, there is limited data on the extent and influence of the use of such infrastructure which could hurt the massive ICT infrastructural investments that have been undertaken to date, particularly about subjects such as chemistry which are challenging to master or grasp by many learners in Ghana.

The paucity of research especially about the use of digital media learning in abstract and complex topics such as organic chemistry demand that studies be undertaken to ascertain the efficiency of the use of the method in supporting classroom instruction in such specific area of learning. This study, therefore, sought to determine the extent and effect of use of digital media in teaching and learning of organic chemistry in secondary schools in Efuttu municipality with requisite ICT infrastructure in an attempt to contribute to bridge the existing knowledge gap.

2.12 Teachers' Philosophy and Use of DMI Tools

Educational philosophy is a way of thinking that questions or peruses science education, goals, objectives, content, the relationship between the ideologies that connect education and practice and the limits and challenges of education as well as techniques. (Köse, 2019). It is also defined as a discipline that analyses, evaluates and interprets concepts and practices that pertain to education and that desires to revolutionize education based on these interpretations (Sönmez, 2019). It synchronizes together the research data of educational philosophies, science education, and other related disciplines (Köse, 2019). Similarly, it shapes the teaching and learning classroom. It also gives ideas to teachers on how to implement the outcome of teaching and learning theories in the classroom environment (Ergün, 2018).

Wiles and Bondi (2007) classified educational philosophies under the following categories: perennialism, essentialism, progressivism, reconstructionism, naturalism, and existentialism. Teachers‘ educational philosophical preferences have impacted their educational understanding and their perception on the use of technology (Duman & Ulubey, 2008). The use of digital media technology in education has become key. In fact, studies have been conducted to highlight the importance of digital teaching tools in terms of the teaching and learning procedure (Karabatak, Aslan & Karabatak, 2022). It can therefore be proposed that teachers should have digital literacy skills in order to be able to deploy digital teaching tools in a qualified manner in the teaching and learning process.

Educational philosophies are founded on two main bases: contemporary and traditional. dynamism is the pillar of progressivism and reconstructionism which are among the contemporary educational philosophies. Teachers who have adopted these philosophies are frequently building their professional capacity and keeping up with change. On the other hand, perennialism and essentialism, the traditional educational philosophies require that the existing structure remain the same and be maintained forever. In fact, having imbibe these educational philosophies, teachers heavily employ conventional teaching methods in the teaching and learning process, and rely on teaching tools such as whiteboards, markers, and books (Sönmez, 2019; Tezei, 2009). Teachers imbibing traditional educational philosophies do not prefer to use digital teaching tools in the teaching and learning classroom (Duman & Ulubey, 2008). Based on this reason, it is probable that teachers' educational philosophies have an effect on their digital literacy and skills. It can also be asserted that their resistance to change has a mediating role in this. This is because it can be stated that teachers who adopt a contemporary education philosophy keep up with change and build their professional capacity but those with traditional education philosophies resist change and strives to maintain the existing structure. Change is defined as the voluntary or involuntary transformation of a system from one form to another (Ives & Jarvenpaa, 1991).

Behavioural change, meanwhile refers to actions by which a person alters an important component of his system such as his tradition, technologies, the infrastructure he uses to operate his internal processes (Stobierski, 2020). Every person has to experience a transformation or change in order to live. Like all other persons and organizations, educational systems change over time due to the pressure of the environment they are in (Yılmaz & Kılıçoğlu, 2013).

Changing practices in schools involves different approaches to the curriculum, management structure, students and teachers, and adaptation to these changes requires flexible school structures (Rosenblatt, 2004). Moral values, advanced technology, administrative systems, and meeting the cravings (needs) of the school community all put pressure on schools to alter their internal processes or transform its system Yılmaz & Kılıçoğlu, 2013). For this reason, most responses to situations occur in three ways which are affective, behavioural, and cognitive.

In conjunction with Piderit's (2000) assumptions, Oreg (2006) similarly, concluded that resistance is a tripartite negative interest towards change, which includes affective, behavioural, and cognitive proponents. Nevertheless, these proponents are not autonomous of each other. The need for change is dynamic. Moreover, individuals experience equilibrium and routine in their duties or responsibilities. Furthermore, in these cases, adamant individuals' performance decreases while those who embrace and integrate innovation and change perform better (Oreg, 2017). Resistance to change makes change difficult and insurmountable. It is a kind of clog or barrier that hinders progress as it can create negative interest such as apathy, loss of motivation, intention to quit, or attempts intended to hinder the change process (Vrabcová, 2015)

As educational institutions, schools are organizations that must adapt to their environment and operate comfortably with new structures, policies, and procedures. In recent years, developments in digital technologies have led schools to face constant change. It should not be forgotten that one of the elements of success in educational organizations is the teacher (Darling-Hammond, 2000). It is extremely important to know teachers‛ knowledge and skills, their need for change and their behaviour towards change in educational processes (Aydın & Şahin, 2016). In the face of changes, teachers generally do not have an option, and they are coerced to implement them. However, they can be resistant towards change consciously or unconsciously. Resistance serves as a useful conduit and not a reaction that should be prevented (Furst & Cable, 2008), It is most likely that teachers‛ attitudes towards digital technologies will be critical in the adoption of these technologies within educational environments and that teachers‛ educational philosophies can shape their perception towards digital technology. The complex, cognitive, and emotional skills required for users to work with digital tools include digital literacy skills (Karabacak & Sezgin, 2019). Adoption of change and transformation is easier as a result of digital literacy. It is assumed that teachers who keep abreast of change and adopt contemporary educational philosophies such as progressivism and reconstructionism use digital media learning tools in the teaching and learning environment.

It is crystal clear that technology, and notably digital media has gained prominence in education now. Recent researchers have also consistently and increasingly endorsed the significance of digital literacy in addition to ICT (Ala-Mutka, 2011 Godbey, 2018; Peled, 2021). Hence, it has become inevitable for individuals to pursue scientific, digital and technological literacy. One of the aims of education is to enable individuals to be abreast with innovation and change. Therefore, it is of great benefit for teachers to acquire literacy in digital media technology.

There has been much debacle or argument about digital literacy in the educational arena (Ng, 2012), and the concept is regarded as an indispensable twenty-first-century skill (Vavik & Salomon, 2015). Ng (2012) defined digital media as a subset of electronic technologies that include hardware and software used by individuals for educational, social, or entertainment purposes in schools or at home.

Ng (2012) classified digital literacy into tripartite dimensions these are cognitive, technical and social. The cognitive dimension is associated with the ability to think critically about the research, evaluate, and create the cycle of processing digital information. The technical dimension of being digitally literate in a broad sense, means possessing the technical and operational skills to use ICT for learning and in everyday activities. The social dimension includes being able to use the Internet responsibly to communicate, socialise, and learn. Martin (2008) described digital literacy as developing awareness, interest and abilities regarding digital media technologies.

Adaptation to new or developing technologies is a significant indicator in determining digitally literate individuals (Ng, 2012). Digital literacy is a decisive competence for working, learning, and socialising in the contemporary world (Churchill et al., 2008) and teachers‘ digital literacy is needed to accomplish the educational outcomes demanded by the age. Digital literacy requires the ability to research, produce, and share accurate information, and to possess the skills to use technology in the learning and teaching environment in line with the right use of different technologies (Hamutoğlu et al., 2017). A digitally literate individual is a creative and innovative, skilled communicator, critical thinker, problem-solver and decision-maker, 2018). Since the dispensation we live in is called the digital dispensation, teachers must possess the skills to use digital media tools. It is extremely important that teachers who facilitate individuals‘ educational backgrounds have digital literacy skills. Thus, they can play a significant role in raising individuals with appropriate skills for the twenty-first century.

2.13 IUPAC Nomenclature of Organic Compounds

The concept of IUPAC nomenclature, which is a formal or generic system of naming organic compounds was introduced in 1892 by the International Union of Pure and Applied Chemistry (IUPAC) (Fessenden & Fessenden, 1990; Gillette 2004; Heger, 2003; Solomons & Fryhle, 2008). From Woodcock (1996), there are other systematic nomenclature systems that came prior to the IUPAC system and that IUPAC names may not be the most commonly used one. Klinger, Kolarik, Fluck, Hofmann-Apitus, and Friedrich, (2008) noted: common names can be searched for with a dictionary-based approach and directly mapped to the corresponding structure at the same time. But IUPAC and IUPAC-like names are identified concerning the structure of the organic compound (Kolarik et al., 1999)

In using the IUPAC nomenclature system to name and write structural formulae of organic compounds, the functional group (which is an atom or group of atoms largely responsible for the chemical behaviour of organic compounds) of a compound is taken into consideration (Gillette, 2004; Woodcock, 1996). For instance, all alkanoic acids and alkanols contain the carboxyl (─COOH) group and hydroxyl (─OH) group respectively bonded to carbon atoms. From Skonieczy (2006), preference should always be given to a functional group that has the highest precedence when the organic molecule in question contains more than one functional group. The principal functional group is usually named as the suffix and the others as the prefixes.

Students‘ ability to translate the IUPAC name of an organic compound into its structural formula is the most important and most flexible as compared to the ability of chemistry students to give the IUPAC name of any given structural formula. In any chemistry examination, if students find it difficult to write a structural formula of any named compound then they will as well find it difficult to understand what the examiner is looking for. Hence, the performance of such students is affected on such questions (Clark, 2000).

Woodcock (1996) explained that though almost every organic compound contains carbon and hydrogen atoms, the names of these two elements do not appear directly in the names of the respective compounds. The IUPAC names of organic compounds are influenced partly by the number of carbon atoms in the longest continuous carbon chain (Woodcock, 1996).

In the simplest form, there are three parts to each organic molecule. These are a root, which shows the number of carbon atoms in the longest continuous carbon chain, and a suffix (ending), which shows the family to which the organic compound belongs. The third part is prefix, which is dependent upon the number, position and identity of any atoms or groups of atoms that have replaced any hydrogen atom or atoms in the parent compound (Gillette, 2004; Woodcock, 1996).

Gillette (2004) stressed that if any chemistry student can learn to apply and interpret these three parts of organic compound names then he or she will be able to write the chemical names of organic compounds based on their Lewis structures and draw the Lewis structures for organic compounds based on their IUPAC names. The same will be true for condensed structural formulae and line-angle drawings.

Gillette (2004) revealed that there are three ways of representing the IUPAC names of organic compounds with structural formulae. The first is the Lewis structure (referred to as the expanded structural formula). The Lewis structure shows all the carbon and hydrogen atoms together with any other atom or group of atoms and the covalent bonds connecting them. The second structure is the condensed structural formula, which shows any carbon atoms in the straight chain together with any other atoms or group of atoms connecting to the chain without the covalent bonds or any unshared electron pairs. In the condensed structural formula, the covalent bond is shown only and only if there is a need to clarify a specific portion of the structure (Gillette, 2004).

From Gillette (2004) sometimes for clarity, we use a combination of a line-angle drawing and a condensed structural formula to depict a cyclic hydrocarbon). Gillette (2004) said to draw the structure of an IUPAC-named compound; we work backwards through the compound name, from the ending to the parent name to the prefix. Clark (2000) explained that an IUPAC name of an organic compound is simply a code and that each part of the IUPAC name reveals some useful information about the compound. For example, 2-methylpropan-1-ol could be understood in the following ways:

1. The prop- shows the number of carbon atoms in the longest continuous carbon chain (and in this instance, there are three atoms of carbon) (Clark, 2000).
2. The –an that comes immediately after the ‗prop' shows there is no carbon-to-carbon multiple bond (Clark, 2000).
3. The 2-methyl and -1-ol show what is or is happening on the first and second carbon atoms in the longest continuous carbon chain (Clark, 2000).

   Clark (2000) was of the view that one has to learn the codes for a number of carbon atoms in a continuous carbon chain to name organic compounds.

Table 1 shows the codes for each group of number of carbon atoms in a continuous carbon chain.

Table 1: Codes of the First five Groups of Carbon Atoms

Code	**Number of carbons**
Meth	1
Eth	2
Prop	3
But	4
Pent	5

Clark (2000) pointed out that if an organic compound contains carbon-carbon multiple bonds, the two letters that come immediately after the code for the chain length will give an indication. Table 2 shows the codes for carbon-carbon single and multiple bonds.

Table 2: The Codes of Carbon-Carbon Bonds

Code	Interpretation
An	The molecule contains only carbon-carbon single bond
En	The molecule contains a carbon-carbon double bonds
Yn	The molecule contains a carbon-carbon triple bonds

Alkanes with more than two carbon atoms can provide more than one derived group. For example, two groups can be derived from propane; namely the propyl group is derived by the removal of a terminal hydrogen, and 1-methylethyl or isopropyl group is derived by removal of hydrogen from the central atom. Alkyl groups such as methyl (CH_3─), ethyl (CH_3CH_2─), and propyl ($CH_3CH_2CH_2$─) are usually attached to the longest continuous carbon chain (Clark, 2000)

2.14 Students' Factors and the Use of DMI Tools

2.14.1 Students Demography

Empirical data from several research studies have indicated that there is an effect of students‛ demographic factors (age, gender, socioeconomic status etc.) on academic performance. There is a paucity of research information on the relationship that exists between students‛ age and the use of digital media resources such as software and computer graphics precisely, Drent and Meelissen (2008), in research conducted on the effect of the use of ICT on students‛ age (15-20 years) stated that the ICT tools rather than unilaterally impacting performance based on the learning variables mediate between interest and other learning variables that are related to the growth and development of students and their higher order cognitive skills.

Earle (2002), also argued that digital media tools enhance the development of metacognitive skills among students therefore boosting efficient learning approaches amongst students, greater participation with learning materials, activities and leading to improved performance. Likewise, Nduati (2015) observed that DMI as an instructional strategy affects a specific age of students in a significant manner. His research findings juxtapose with that of DeMeis and Stearns (1992) who realized an insignificant mean difference in the performance of students exposed to DMI based on age. They thus exclusively concluded that academic performance is a product of personal perseverance, cognitive development and interest as well as other positive correlates. Chansarkar and Michaeloudis (2001) and Ugoji (2008) also posited that age is not a determinant of students' performance but is to some degree linked to their entry behaviour. Some researchers have proposed concerning gender that male students due to certain characteristics tend to profit more than their female cohorts when ICT and other digital media resources are scanty. (Nawe, 2002).

The researchers, therefore, entreat that special attention should be paid to female students during the allocation of the instructional tools and the teaching process. This is because there is a tendency for male students to assume the predominant operator role in learning situations where the instructional environment is faced with insufficient DMI tools including computer hardware. Sanga, Magesa and Kayunze (2011) propose that the inequality of female students to access DMI resources and ICT infrastructures just as their male colleagues may be a result of gender factors. Males tend to be more active in computer-related classroom discussions, make more spontaneous comments and are also asked more questions by teachers. Females, the report noted tend to lack confidence in computing and most often underestimated their computer-related competence. According to some research information, the pivotal role that education can play in unlocking ICT-related opportunities demands that access to new information technologies such as DMI be made more feasible for girls and women (Hafkin & Taggart, 2001; Rathgeber, 2001). At the very least, they insist that ICTs should be equally accessible to boys and girls. Gender activists propose that since it is assumed that when girls enter adolescence, many of them tend to lose interest in science, math, and computer technology, focusing on a curriculum that emphasizes learning specific computer skills out of context may discourage them from using computers. However, when conditions are provided where they can easily access the tools in more conducive circumstances, they may profit more thus facilitate their learning.

According to Wu, Krajcik, and Soloway (2001), many students learning chemistry have challenges learning symbolic and molecular representations. They, therefore, conducted a study with 51 eleventh-grade students of a small public high school in a midsize university town in the Midwest to investigate how Chemistry students develop and understand chemical representations using a computer-based visualizing tool for 6 weeks. To them, the computer-based visualizing tool was referred to as e-Chem. One of the chemical concepts studied within the 6 weeks by Wu et al. (2001) was IUPAC nomenclature of organic compounds such as hydrocarbons.

Wu et al. (2001) pointed out that with the help of e-Chem; the chemistry students were able to apply modern rules of IUPAC nomenclature to draw structures of some given organic compounds. For instance, the students were made to name and draw the structure of a six-carbon atom compound with a side group. The understanding of the high school Chemistry students used in the study was said to have improved reasonably resulting in high performance on IUPAC nomenclature of organic compounds. This is based on the fact that there was a statistical significant difference between the means of pre-test (N = 71, M = 31.1) and post-test (N = 71, M = 59.5) results after they had been subjected to a paired two-sample t-test analysis (SD 2.5, t(70) = 13.9 p 0.001) with an effect size of 2.68 (Wu et al., 2001).

2.15 Teachers' Factors and the Use of DMI Tools

2.15.1 Teachers' Wellbeing and Use of DMI Tools

Touching on the overview concept being explored in this study concerning teachers' well-being from the adoption and integration of digital media technologies. There is very limited and detailed research knowledge available currently. Some current studies have focused more specifically on the development of teacher well-being as an outcome. For example, Rymmin, Kunnari and Fonseca D'Andréa, in a review of a teacher education programme with Finnish and Brazilian teachers stated that teachers consciously constructed networked expertise and socio-psychological well-being by applying digital solutions creatively, and this had a positive impact on their pedagogical practices.

A possible way to paraphrase and model teacher well-being, a result of the use of innovative digital technologies has been proposed by De Pablos-Pons et al (2013). Research data reviewed proves that teacher well-being can be affected by a psychological frame of mind, social economic and physical sources, over all three needs of competence relatedness and independence. Savill-Smith, from research data on teacher well-being, pointed out critical issues and factors that affect positive or negative well-being results. In her study, factors were examined specifically through a lens focused on socioeconomic lifestyle and mental health issues.

Out of the 1019 educational professionals involved in the participant sample, 62% described themselves as stressed (increasing to 84% for senior leaders), 38% considered the inability to switch off their mood to be the key contributing factor to a negative work-life balance, 68% experienced behavioural, mental or physical symptoms due to their work, and 51% of school teachers attributed work symptoms to pupil student attitudinal issues. In this context, within the report studied, four factors were identified as contextual and important, all of which related to the adoption and integration of digital media technologies by educational professionals. These four factors were work and life balance, symptoms experienced, work issues and mental health issues. The groups of factors and individual factors are:

- Work/life balance—factors which contributed a great deal or somewhat to a negativework–life balance, inability to switch off and relax, working long hours on weekdays, not finding time to be with family and friends, working over the weekends, working during holidays, family commitments preventing them from doing a good job at work.
- Symptoms experienced linked to possible signs of mental health issues, self-defined or suggested by someone else, anxiety, depression, exhaustion and acute stress.
- Work issues that symptoms were related to: excessive workload, work and life balance; students' attitude, low income, rapid pace of change (e.g., National Curriculum), problems with students' parents, lack of opportunities to work independently.

Discrimination; Ways in which mental health problems experienced at work were alleviated: physical exercise, meditation, mindfulness and counselling related to these causes, the Office for Standards in Education (Ofsted) in England stated in a recent report on teacher well-being in schools stated that teachers who love their profession or overwhelmingly enjoy teaching, are generally very positive about their workplace and colleagues and enjoy building relationships with students and seeing them flourish but that these are balanced against negative drivers, high workloads, lack ofwork–life balance. They sometimes feel the profession does not receive the respect it deserves. From the data reviewed in the literature above, it is clear that teacher wellbeing is not only an issue that needs to be examined deeply but it is an issue that warrants further studies that can look for avenues to address the challenges that teachers face.

The main factors that affect teacher well-being need also to be perused in terms of intrinsic and extrinsic motivation. This wider motivational perspective was outlined in the Savill-Smith report whilst education professionals stated that they enjoyed different aspects of their work, they also indicated that an equally important concern for them was to make a difference in the lives of students. Helping students to achieve their potential, as well as the quality of interactions they had with their students, were additional and important underlying concerns. Interventions that can enhance these positive reasons for teachers being involved in their work and that can help to alleviate problems that they experience will support more positive teacher well-being.

2.16 Availability of DMI tools

Researchers in time past have shown through their studies that the availability of ICT infrastructure and resources in schools is a critical criterion for the efficient and effective adoption of ICT in education (Plomp, Anderson, Law & Quale, 2009).

Albirini (2006) in his research findings revealed that though 67% of the respondent teachers acknowledged having access to computers at home, only 33.3% could access the tool in school implying that teachers in this particular research study had insufficient access to computers.

The availability of digital media and ICT resources has been shown to impact negatively the adoption and integration of resource facilities. Buabeng-Andoh (2012) citing Afshari, Bakar, Luan, Samah and Fooi (2009) revealed that while over 50% of teachers who participated in their study indicated using computers for research and lesson preparation in their schools, about 78% of the respondents complained of inadequate access to computers in classroom. In particular, 38% maintained that while inadequate computers were not great barriers to ICT use in their teaching, enhanced availability and equality of access to digital media tools by teachers, students and supportive staff is important. Citing Tondeur, Valcke and van Braak (2008), Buabeng – Andoh (2012) is emphatic that access to digital media tools is not only important but also the validity and reliability of the tools and facilities to support teaching and learning is also important.

Friedhoff (2008) as cited in Chen (2010) stated that the availability of appropriate and suitable digital tools means that the cost and efficiency of a digital tool need to be factored in when the tool is being adopted and integrated into classroom lessons. For instance, in a study of preservice teachers by Dexter and Reidel (2003), they revealed that 37.4% of the teachers had access to computers and 14.4% of the students had access to computers, implying that computers are more available to teachers than students. To encourage student-centered technology learning, it is necessary that learners have access to quality technology resources. Availability and fairness of access to the resources by teachers, students and administrative staff is essential. Citing Tondeur, Valcke and van Braak (2008), Buabeng – Andoh (2012) is categorical that access to the tools is not only important but also the suitability of the available tools and program to support teaching and learning is equally important.

Friedhoff (2008) as cited in Chen (2010) maintains that access to appropriate technology means that the affordances and constraints of a technological tool need to be carefully considered when the tool is being incorporated into a lesson. For instance, in a study of preservice teachers by Dexter and Reidel (2003), they revealed that 37.4% of the teachers had access to computers and 14.4% of the students had access to computers implying that computers are more available to teachers than students. Obviously, to encourage student-centered digital learning, students must have access to quality digital media resources.

2.17 Demography of Teachers and Use of DMI Tools.

Demographic conditions have been described as the main conditions that may predict or affect the integration and adoption of digital media learning tools by teachers. Among the demographic conditions that are often stated as affecting digital media learning include the following: gender, income status, educational qualification, age and abilities (UNDP, 2011; Inan and Lowther, 2009). Demographic conditions such as age, gender, teaching experience, computer use experience and educational qualification would be considered. The study researcher is not aware of any study report that has investigated the combination of demographic conditions and digital media access as factors that affect digital media use among science teachers in public schools in Ghana.

Therefore, this study likewise investigated the extent to which demographic variables such as age, gender, subjects taught, educational qualification and teaching experience as well as the degree of digital media accessibility and location affects digital media use among science teachers in public schools in Ghana. Studies concerning teachers' demographic conditions and the integration of digital media tools have also yielded contradictory results most of which have been based on survey studied. Research reports have cited insufficient female teachers�What adoption of technology use. A fact they have attributed to limited access to digital media infrastructure, low competence and apathy (Volman & van Eck, 2001 as cited in Buabeng – Andoh, 2012). Kay (2006) as cited in Buabeng– Andoh (2012) maintains that male teachers‘ digital media use is predominantly higher compared to female teachers. Markauskaite (2006) and Jamieson-Proctor, Burnett, Finger and Watson (2006) as cited in Buabeng – Andoh (2012) also agreed that female teachers‘ degree of integration of digital media in classroom teaching was less than their male counterparts.

Contrast reports by Breisser (2006) and Yukselturk and Bulut (2009) were also provided in their research. For Breisser (2006), report findings acknowledged enhanced female teachers‘ self-belief about technology skills and competence while that of their male counterparts remained constant or static. Yukselturk and Bulut (2009) specifically confirmed based on their research reports that female teachers were more presumable to adopt digital media tools in classroom learning than males. Furthermore, Gordon (2003) and Norris, Sullivan, Poirot and Soloway (2003) as cited in Buabeng-Andoh (2012) confirmed that gender as a condition or variable is not an indicator of digital media integration into instruction. This study reviewed the concept of gender dynamism in digital media integration in the instruction of organic chemistry in public secondary schools to determine the Ghanaian teachers' views. Previous and current researchers hold contradictory views on the effects of teachers‘ educational qualifications and experience on their level of adoption and integration of digital media tools. Alazzam et al. (2012) found a relationship between teachers‘ educational qualification and their apathy towards digital media instructions.

Lau and Sim (2008) indicate an existence of effect of the level of teachers‘ educational qualification on digital media adoption. This submission in tandem with those of Mahmud and Ismail (2010) indicated that digital training contributed to teachers‘ digital literacy significantly. Similarly, Tezci 2009), showed that teachers‘ level of educational training had a significant effect on their digital skills and yielded effective results in the use of digital media tools in classroom teaching.

The working experience and expertise that a teacher has built in the teaching profession has been shown to be an important indicator of their classroom practice (Buddin & Zamarro, 2009). Relative to technology integration, there are conflicting opinions by researchers on how experience plays a prominent role in teacher‘s ability to adopt digital media. From the divergent views, two trends emerge. The first trend denies the existence of any link between experience and teachers‘ use of digital media tools. (Niederhauser & Stoddart, 2001 as cited by Buabeng – Anduh, 2012). Other believers of this school of thought such as Granger, Morbey, Lotherington, Owston and Wideman (2002) as cited by Buabeng- Anduh (2012); Russell, O'Dwyer, Bebell and Tao (2007).

They each conclusively believe that there exists no statistically significant relationship between teachers‘ experience in teaching and use of ICT tools. Similar observations can be attributed to Alazzam et al., (2012) and Mueller, Wood, Willoughby, Ross and Specht (2008) who each did not find any significant effect of teaching experience on teacher readiness to integrate ICT in teaching. Proponents of the second school of thought maintain that there exist a link between teaching experience and use of ICT tools (Giordano,2007; Hernandez-Ramos, 2005 as cited by Buabeng-Anduh, 2012; Wong & Li 2008).Gorder (2008) for instance is categorical that teaching experience significantly affect use of technology, an assertion also supported by Baek, Jong and Kim (2008) as cited by Buabeng-Anduh (2012).

Similar views are held by U.S National Centre for Education as well as Inan and Lowther (2009) who found that years of teaching experience affect teachers‘ computer proficiency negatively. Ertmer (2005) is equally categorical that teachers‘ work experience influences their readiness and beliefs in digital integration in teaching. This study intended to make it contribute its quota by including a Ghanaian dimension into the academic discourse.

2.18 Capacity Building and Use of DMI Tools

Professional development is an important factor that is perceived to promote effective integration of ICT in the classroom. Some studies have alleged that though ICT tools such as DML were accessible in schools, teachers were still mainly employing conventional instructional methods for classroom instruction and were not making the necessary effort to integrate ICT to create innovative learning experiences for their students (Jules-Van-Belle & Soetaert, 2001).

Others maintained that though some were making effort to integrate technology, the level of use was still not effective enough (OECD, 2001). The malaise in DM integration according to these studies is attributed to teachers�either attitude towards computer use (Norris et al., 2003) and an improper instructional reform based on improper instructional philosophy (Selwyn, Dawes & Mercer, 2001). Teachers, the researchers argue need knowledge of appropriate ICT integration strategies and skills to effectively adopt the tools in their lessons and optimize the benefits for their students‘ learning (Pedretti, Mayer-Smith & Woodrow, 1999). Therefore, teachers‘ professional capacity building has to focus on both ICT skills training as well as appropriate DM adoption strategies in the curriculum and syllabus (Divaharan & Koh, 2010) as a panacea to the instructional loophole.

Since digital media in education is considered as a relatively new innovation in schools, professional capacity building is a major factor to its successful adoption into classroom teaching. Several research studies have shown that whether naïve, amateur or experienced, digital media related training programs strengthens teachers‘ competences in computer use (Bauer & Kenton, 2005; Franklin, 2007), boost teachers‘ interest towards computers (Hew & Brush, 2007; Keengwe et al., 2008) as well as aiding to teachers restructure the task of technology and how new technology tools are significant in student learning (Plair, 2008). Muller et al. (2008) related digital media technology training to successful adoption of technology in the classroom. They posited that professional capacity building and the continuing support of good job ethics are among the greatest predictors of successful digital media learning adoption.

Research has consistently demonstrated that the effectiveness of adopting digital tools in education is contingent upon teachers' digital skills and their motives for utilizing technology (Vanderlinde, van Braak, & Hermans, 2009; Venezky, 2004). These factors play a crucial role in determining the overall success and impact of integrating digital resources in instructional practices.

This is because professional development is achieved by observing colleagues, engaging in teachers�be peer teaching, observation of each others‘ digital-integrated lessons, as well as the provision of opportunities for teachers to share and engage in collaborated teaching (Flanagan & Jacobsen, 2003; Prain & Hand, 2003). Sandholtz and Reilly (2004) as cited in Buabeng – Anduh (2012) acknowledge that teachers‘ digital skills strongly indicate the depth of digital media use in classroom teaching and activities. Teachers, the research data posited should therefore be exposed to programmes that strengthens their mastery of pedagogical skills related to digital media tools.

This observation is also supported by other researchers including Brinkerhoff (2006), Diehl (2005) and Lawless and Pellegrino (2007) as cited in Buabeng-Anduh (2012). Buabeng – Anduh (2012) specifically posits that experts in technology should be accessible to teachers to guide them on how best to integrate digital tools to facilitate students‘ learning an observation earlier supported by Chen (2008), Lawless and Pellegrino (2007) and Plair (2008) as cited by Buabeng-Andoh (2012). Generally, the researchers agree that teachers‘ understanding of content knowledge and how to apply technology to support students‘ learning and attainment is linked to their increase in knowledge level, confidence and attitudes towards technology.

2.19 Administrative Support

Melton and Burdette (2011) suggested administration would become easier if technology could effectively organize a student-centered learning. For instance, a database could be made for all digital media used in chemistry. The digital media would provide documentation on syllabus or subject alignment or an institution's vision of digital media literacy (Gourlay et al., 2014; Heo, 2009). To my knowledge, no empirical research has evaluated administrative efforts in specifically implementing digital media learning.

The table below shows administrative support indicating specific administrative support and their appropriate practices.

Table 3: Administrative support

INSTRUCTIONAL GUIDELINES	APPROPRIATE PRACTICES
Daily Support	School administrators have a full responsibility to oversee the integration and implementation of digital media learning policy.
Advocacy	School administrators should advocate the importance of the program and support the integration within the school and among community stakeholders
Policies and Procedures	Program should align all DMI with the institution's Guideline
Instruction Environment	Teachers are able to effectively teach in contribution to class-size and equipment availability.
Funding, Resources, Equipment, and Facilities	School administrators ensure financial support is allocated toward the program and all digital media infrastructures.

Source. NASPE (2009)

As a major industry player in the daily operations of a school, the administrator plays a key and focal role in the realization of learning outcomes (Ayot & Patel, 1992). Digital media are frequently used and seen as important in all spheres of the society including education. This needs an efficient, vibrant and dynamic school administrator. Present day school administrator faces countless challenges related to educational technology (Omwenga, 2005). Sife et al. (2007) linked administrative support to the successful utilization of digital media instruction. It is crucial that administrators provide enabling conditions that are needed such as incentives and resources.

This suggestion is also supported by Ndiritu, Gakuu and Kidombo (2012) who assert the fact that commitment and interest of an institution's top management and other leaders at every level is the most critical factor for successful implementation of digital media learning within the institutions Cameron and Ulrich (1986) as well as Dwyer, Ringstaff and Sandholtz (1997) as cited in Sife et al. (2007) proposed dynamic and futuristic leadership in schools ready to adopt principal change which is required for the institutions to adapt to changes brought about by the digital natives. Specifically, Dwyer et al. (1997) as well as Sife et al. (2007) emphasize that for the integration of digital media to be effective, administrators themselves must be competent in the use of the technology, and they must have a broad understanding of the technical, pedagogical, administrative, financial, and social dimensions digital media in education.

It is also the argument of Anderson and Dexter (2005) that though physical and technical support is crucial, school technology leadership is a stronger influencer of teachers' use of computer technology in teaching. Yee (2000) believed that a leader who implements technology plans and also shares a common goal with the teachers inspire them to utilize technology in their lessons. Lai and Pratt (2004) suggests that for effective utilization of digital media by teachers, there is the need for a strong leadership drive and well-designed technology plan in schools. Becta report on the effect of digital media tools on teaching in basic schools in United Kingdom also stressed on significance of good leadership (as cited in Lai & Pratt, 2004). The report identified five factors that are considered essential for schools if digital media learning tools is to be utilized properly. These factors include physical resources, digital learning, digital media driven leadership, general teaching and general school leadership. Leadership support to digital media integration include observations of researchers such as Afshari et al. (2009), Ng (2008) as well as Wong and Li (2008) as cited in Buabeng-Andoh (2012).

For instance, in citing Wong and Li (2008), Buabeng-Andoh (2012) indicated that good leadership promote cooperation, experimentation and teacher‛s commitment to student-centred learning which influence digital media integration. Similarly, Ng (2008) as reported by the same researcher revealed that a transformational leadership with qualities of identifying and articulating a vision, promoting acceptance of group goals, providing individualized support, offering intellectual stimulation, providing an appropriate model, creating high performance expectations, and strengthening school culture could influence integration of digital media learning tools. Commenting on the same issue Afshari et al. (2009) concluded that transformational leadership could help improve integration of digital media into teaching and learning processes. Other researchers in support of this line of argument include Anderson and Dexter (2005) and Yuen, Law and Wong (2003). Administrative leadership shows the direction and thrust of an institution towards learning programmes that are to be adopted into the institution (Ayot & Patel, 1992). The eagerness with which institutions implement e-learning among their students and staff is based on the institutional leadership's thrust and initiatives towards the realization of this goal (Ndiritu et al., 2012).

There are conditions that administrative leaders have to meet to enable implementation come to reality. One of the most crucial caveats for successful implementation of e-learning is the need for careful consideration of the underlying pedagogy, or learning management system. (Govindasamy, 2002). This aunus lie on administrative leaders to ensure that the right strategy is adopted and the appropriate resources and motivation is inculcated in those whose task it is to finally implement e-learning. Implementation of digital learning in schools according to available empirical data faces several challenges. These according to Mwalongo (2011) include limited digital facilities, expensive internet connectivity, limited skills for digital learning integration and inadequate workforce due to the failure of training institutions to produce IT technicians and professionals needed for the labour market. Similar sentiments were reported by Mendes, Tuijnman and Young (2003) as well as Swarts and Wachira (2010) as cited in Mwangolo (2011). Other challenges according to the researcher include limited electricity supply and inadequate number of computers.

2.20 Technical Support.

Technical support required for digital media integration includes installation, operation, repairs, network administration and storage of the tools (Sife, Lwoga & Sanga, 2007). This forms an important component of the implementation and integration of digital media tools. Digital media integration in most developing countries lack or enjoys minimal technical support (National Committee for WSIS Prepcom II, 2003, as cited in Sife, Lwoga & Sanga, 2007). Basic training should be given to teachers and even at times students so that they are able to troubleshoot technical problems whenever they arise. Appropriate strategies should be put in place to ensure that integration of digital media in teaching and learning process goes together with recruitment, training, retraining and retention of staff with appropriate skills and expertise in the tools. Jones (2004) reported that lack of technical assistance during breakdown of a computer causes interruptions thus discouraging teachers from using computers, Becta (2004) asserted that lack of technical support available in a school impede maintenance resulting in a higher risk of technical breakdowns. Yilmaz (2011), on his part advices stakeholders that in providing schools with ICT hardware and internet connectivity, it is also crucial that technical support be availed to enable repair and maintenance that would ensure the continued use of ICT tools in schools. Empirical data associate lack of technical support for a school‘s technology needs with teachers‘ frustration and unwillingness to use the technology tools (Korte & Husing, 2007 and Tong & Triniada, 2005 as cited by Buabeng- Andoh, 2012). Collectively, the researchers insist that if there is no technical support, teachers in the course of integrating often become frustrated resulting in their unwillingness to use digital media tools..

2.21 Summary of Literature Review and Research Gap

Numerous bodies of research have been done with respect to digital media learning integration in Ghana educational institutions. However, there is inadequate research information that highlight and assess the extent and effect of integration of digital media in organic chemistry lessons. The general results/expectation from research done on digital media integration are relevant ,specifically, to integration of digital media in teaching and learning of organic chemistry, an important area of chemistry education in the secondary schools' curriculum. This is the basis upon which this study set out to assess the effects of use of digital media instruction in the teaching and learning of organic chemistry nomenclature in public secondary schools in the central region of Ghana. There is a consensus from previous research findings that digital media tools positively affect the performance of students in the classroom. It is also widely acknowledged that various digital media tools are best suited for instruction of specific areas of the curriculum. Similarly, while a lot of resources have been used to provide the digital media tools such as those used in integration of digital learning, availability of resources does not necessarily guarantee their use. Still, it is alleged that some of the resources available may not necessarily be appropriate for classroom pedagogy. More importantly, it has been seen in other instances that more effort has been expended in making the resources available while little regard is given to the users of the resources who could be ill prepared to use them. The existing knowledge gap is to evaluate optimal levels of use of available digital learning tools to ensure an enhanced classroom environment particularly with regard to chemistry a subject in which a majority of students have persistently posted poor performance in succeeding years both at the district and national level in Ghana.

CHAPTER THREE

RESEARCH METHODOLOGY

3.0 Overview

This chapter describes the method that was used to carry out the research study. It provides detailed outlines of the research approach, research design, location of the study, population of the study, sampling and sampling technique and sample size. Also, other information included in this chapter are instruments for data collection, the trial phase for pretesting the instruments, reliability and validity, procedure used for data collection, methods of data analysis and respondents‘ ethical considerations.

3.1 Study Area

The study was conducted within the Coastal area of the Central region of Ghana. Chemistry performance in the area has been poor for many years. Therefore, studies on treatment such as the current study were deemed necessary. The larger administrative unit was selected to obtain a wide and varied study sample.

3.2 Research Approach

A research approach is very important since it guides the research on what to do. This study adopted a quantitative research approach. According to Bhandari (2020), the quantitative research approach is defined as the process of collecting and analyzing numerical data. It can be used to find patterns and averages, make predictions, test causal relationships and generalize results to wider populations. The advantages of this approach according to Bhandari (2020) are that the study can be reproduced in other cultural settings, time or with different groups of participants. Results can be compared statistically. Also, data from large samples can be processed and analyzed using reliable and consistent procedures through quantitative data analysis. Finally using formalized and established hypotheses testing procedures means that you have to carefully consider and report your research variables, predictions, data collection and testing methods before concluding.

3.3 Research Design

The main objective of this research study was the integration of digital media in the instruction of organic chemistry nomenclature and its effect on secondary school students' academic performance. To achieve this, the research study adopted a non-equivalent quasi-experimental design. In this design, the study sample was divided into two groups, one of which was experimental while the other was control. The first group was an experimental group and was tested before and after receiving treatment. The second group was a control group, which was tested before and after teaching with the conventional method of teaching.

Table 4: Research Rubric for quasi-experimental Design

Group	Pre-test	Treatment	Post-test
E	O1	X	O2
C	O3		O4

Key: E: Experimental, C: Control, X: Treatment, O: Observation
Source; Authors' own construct.

The quasi-experimental design, according to Johnson and Onwuegbuzie (2004), gives strong evidence for treatment and allows evaluation of both testing effects and confounding variables which is possible in either the two- group pre-test-treatment post-test models. The quasi-experimental research incorporates the advantages of the two- group pre-test-treatment post-test. Fraenkel and Wallen (2006) support the use of this method because it is considered sufficiently rigorous and appropriate for students at the pre-tertiary level. Cohen, Manion and Morrison (2011), on their submission find it appropriate since it gives sufficient control of the extraneous variables that would have affected both internal and external validity of the study which include student interest towards chemistry and their demography such as age, gender and socioeconomic status.

Quasi – experimental design was adopted because it was not possible to assign individual participants to groups randomly. Receipt of permission to include students from schools as participants in the study was also based on the fact that they would be kept within their existing classrooms to ensure infinitesimal external interference with their learning activities. Moreover, entire classrooms and not individual students were assigned to various treatment groups. Since random assignment was not possible, quasi experimental designed was found to be the ideal method. Also, to minimize effects of internal validity, conscious effort was made to include groups of students with similar characteristics (elective chemistry students,same level ,etc) as much as possible. This also enabled the researcher to minimize possible effects from reactive arrangements (Gay, Mills & Airasian, 2009).

3.4 Population of the Study

A research population is generally a large collection of individuals or objects that is the main focus of scientific query and it is for the benefit of the population that research is done (Clifford, Michal & John, 2007). The population of the study was all senior high schools in the Central region. For any study, the target population is all the members of a group defined by the researcher‘s specific interest for him or her to answer research questions. However, the target population were all elective chemistry students in senior high schools in the central region. The accessible population where elective chemistry students of Potsin Senior High school and Winneba Secondary School because these schools were closer to the researcher.

3.5 Sampling and Sampling Technique

Sampling refers to the process of selecting a portion of the target population to represent the entire population (Alhassan, 2006). According to Clifford et al. (2007), for a study, the size of the sample selected for the study is immaterial and depends solely on what the researcher is researching. Forty-eight (48) Form 3 science students of Potsin Senior High school and fifty-five (55), comprising 31 males and 24 female form 3 Science students of Winneba senior high school were selected on purpose as sample for the study. Purposive sampling also known as judgmental, selective or subjective sampling is a type of non-probability sampling technique where the units that are investigated are based on the judgement of the researcher (Clifford et al. 2007). Form three students were considered for this study because having had a longer period of exposure to secondary school life they were better placed to provide more concrete information required for this study. More importantly the topic selected for this study is offered in form three having had the introduction to organic compounds in form two.

3.6 Research Instruments

The research instruments that were used in the study for data collection were a pre-test, post-test and two different types of a five-point Likert scale questionnaire ranging from strongly agree to strongly disagree. The tests were used to collect quantitative data from both the control and experimental groups. One 5-point Likert scale questionnaire was used to collect data on students‘ conception of organic chemistry nomenclature from both groups (control and experimental groups). The other set of questionnaires was used to collect data from the experimental group on their views of the use of digital media as a teaching strategy for teaching organic chemistry nomenclature. The pre-treatment and post-treatment tests were made to be equivalent in terms of difficulty but contained different items.

3.6.1 Pre-test OCAT

The pre-test OCAT instrument was prepared on topics of choice that included organic compounds such as hydrocarbons, functional groups and IUPAC nomenclature, thus topics which had previously been covered by all the students involved in the study. The main aim of the pre-test instrument was to test the students‘ ability in organic chemistry. The instrument consisted of twenty multiple choice and ten short structured questions of the Chemistry Paper II type. The pretest was collected and marked after administration. The researcher scored the pre-test out of 100 marks.

3.6.2 Post-test OCAT

The effect of treatment on students‘ academic performance in organic chemistry was tested based on a post-test examination at the end of the treatment phase. The instrument – organic chemistry achievement test (OCAT) for the post-test was prepared by the researcher in collaboration with the two teachers who administered the treatment. It comprised questions intended to measure students‘ organic chemistry proficiency in the two main domains of the topic; nomenclature and properties of organic compounds. Each of the two questions were of Chemistry Paper II category and extensively tested the various domains of Organic Chemistry II subject content. Accumulatively, all questions had a maximum total score of 100 marks.

3.6.3 Students' Questionnaire (SQ)

Two different 5-point Likert scale questionnaires ranging from strongly agree to strongly disagree were administered during the study. The first questionnaire intended to assess students' conceptions of organic chemistry. Items in the questionnaire were adopted from the Scale of High School Students' conceptions about organic chemistry (SHSSCOC) as presented by Demircioglu, Aslan and Yadigaroglu (2014) for use in organic chemistry students' conception studies. The instrument initially contained 10 items constituted by making use of Test of Science-Related Conception (TOSRC) which was designed to measure ten distinct science-related conception among secondary school students. The second 5-Likert scale questionnaire was used to collect data on students' views of the use of digital media in teaching organic chemistry nomenclature.

3.6.4 Trial Test

A trial test was conducted in a mixed secondary school (Uncle Rich SHS) purposively selected. Mixed-sex schools were purposely targeted at this stage since they provided the researcher with the categories of the targeted population in one sitting (has both boys' and girls' students). The purpose of the trial test was to pre-test the research instruments and assess the difficulty level of the achievement test items to be administered to both control and experimental group. Based on the findings of the trial test, the researcher revised the research instruments accordingly.

3.7 Validity of the Instruments

The pretest and posttest OCAT and student's questionnaire were designed using items obtained from credible sources and researchers in chemistry education. For instance, the OCAT were developed from test items developed by examiners of chemistry at the WASSCE level (2005-2019). They were then validated by three experienced secondary school teachers who are also senior WASSCE chemistry examiners. The questionnaires were prepared from previously validated instruments.

3.8 Reliability of the Instruments

The reliability of the students' questionnaire used was estimated using the Cronbach alpha coefficient. A coefficient value of 0.76 was obtained. According to Bhandari (2020), a Cronbach alpha value above 0.70 is presumed to be in the range of acceptable internal consistency. Test-retest method was also used to estimate the reliability of the achievement test items and a correlation coefficient value of 0.78 was obtained indicating that the test items are reliable.

3.9 Data Collection Procedure

The collection of data for this study took place between March and May 2022. These dates correspond with the first and second term of the school year which was chosen because the topic used in the study is usually taught during those dates. First, the researcher sought permission to conduct research from the University through Graduate School. With the approval from the university of education Winneba Graduate school, the researcher sought and obtained permission to conduct the research from the purposively selected schools. The study proceeded in phases. The first phase involved the researcher visiting participating schools to be introduced, familiarize, seek respondent's permission and cooperation and make appropriate appointments. The researcher administered the DMI lessons using chemistry class teachers. Therefore, during this initial period, the researcher met teachers and held discussions with them on DMI and how such lessons could be planned and executed. The researcher, together with the teachers then prepared the DMI lessons. At the same time, the researcher with the help of the respective school‘s IT technician inspected and installed the DMI-supported lesson programs in the desktops and laptops for use later in schools sampled for DMI lessons. Phase two involved the administration of the pre-test instrument to the students and took place in the first week of April, 2022.The sampled students were pre-tested on several topics including organic compounds, hydrocarbons, functional groups as well as IUPAC nomenclature.

The Pre-test OCAT and the SQ were administered on the same day. Phase three involved administration of DMI and conventional treatment methods to the students. The experimental class learnt using computer instructional materials consisting of software, tutorials and simulations. Teachers handling the experimental group were all trained by the researcher on how to administer the DMI enabled lessons. Teacher's role was not only to observe and assess but also to engage with the students while they completed activities, suggesting solutions and posing questions to the students for promotion of reasoning. The control class was taught using conventional methods. The researcher ensured that both control and experimental groups covered the topic within the stipulated time by providing the teachers with a common time-plan (four weeks). Finally**,** the last phase entailed the researcher administering the post-test OCAT instrument to the students and took place at the end of the four weeks treatment duration.

3.10 Data Analysis Procedure

Microsoft Excel (2019) and SPSS statistical tool Version 25 were adopted to analyze the data collected. Z-tests were employed to validate whether or not there was a significant difference between students‘ scores on the pre- and post-treatment tests.

Where necessary measures of central tendency (i.e., mean, mode and median) were used to analyze the data. Analyzed questionnaire data were organized into frequencies and percentages. Research question sources of data, methods of data collection and how the data was collected and analysed are summarized in the table 5 of the matrix below.

Table 5: Data Collection and Analyses Technique

Research Question	**Data Sources**	**Data collection Instrument**	**Data Analyses Technique**
1. What are students' conceptions of organic chemistry nomenclature?	Students	5-point Likert scale questionnaire	SPSS, frequencies and percentages
2. What is the effect of digital media on the students‘ performance in organic chemistry nomenclature?	Students	Post-test scores of control and experimental group	Z-test
3. What are the differential effects of digital media on male and female students‘ performance in organic chemistry nomenclature?	Students	Post-test scores of experimental group	Z-test
4. What are the views of the students on the use of digital media for instructions in organic chemistry?	Students	5-point Likert scale questionnaire	SPSS, Frequency/Percentage counts

3.11 Ethical Considerations

Permission from the Department of Chemistry Education was obtained first, upon the proposal approval.In the researcher obtained research permits from both the district director of education and headmistresses of participating schools to undertake the study. Then, during data collection, subjects were informed in a covering letter about the purpose of the research and issues of their confidentiality. This included the purposes and data collection methods, assurance of subjects' anonymity, subjects' voluntary participation in this study and subjects' freedom to participate or withdraw from the study at any time.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.0 Overview

This chapter is dedicated to showcasing the findings of a research study undertaken to assess how digital media influences the academic performance of senior high school students in organic chemistry nomenclature. The primary objective here is to present and analyze the data derived from this investigation.

4.1 *Presentation of the Results by Research Questions*

The analysed data used to answer the formulated research questions are now presented in the same order as the research questions.

4.2 Research question 1: What are students' conceptions of organic chemistry nomenclature?

The profile analyses of students‘ responses are shown in Table 6

Table 6: Students' Responses to the Questionnaire on Their Conceptions of Organic Chemistry Nomenclature

S/N	Statement	SA F (%)	A F (%)	N S F (%)	D F (%)	SD F (%)
1	Organic chemistry nomenclature is too abstract to learn	23(26.1)	16(18.2)	26(29.5)	18(20.5)	5(5.7)
2	My chemistry teacher makes the learning of organic chemistry nomenclature uninteresting	13(14.8)	21(23.9)	25(28.4)	17(19.3)	12(13.6)
3	I am always excited during organic chemistry nomenclature lessons	9(10.2)	22(25.0)	31(35.2)	11(12.5)	15(17.0)
4	I have a negative attitude towards organic chemistry nomenclature lessons	5(5.7)	9(10.2)	16(18.2)	26(29.5)	32(36.4)
5	I do not enjoy learning organic chemistry nomenclature as compared to other topics in chemistry	16(18.2)	12(13.6)	27(30.7)	26(29.5)	7 (8.0)
6	My chemistry teacher makes learning organic chemistry nomenclature lessons interesting and fun	16(18.2)	21(23.9)	25(28.4)	16(18.2)	10(11.4)
7	I understand organic chemistry nomenclature lessons with less effort	9(10.2)	18(20.5)	32(36.4)	19(21.6)	10(11.4)
8	Organic chemistry nomenclature lessons are interesting but difficult	12(13.6)	21(23.9)	27(30.7)	21(23.9)	7 (8.0)
9	Organic chemistry nomenclature of compounds is easy and interesting	18(20.5)	22(25.0)	22(25.0)	11(12.5)	15(17.0)
10	My chemistry teacher‘s method of teaching is more innovative and helps me to understand organic chemistry nomenclature easily	14(15.9)	19(21.6)	27(30.7)	16(18.2)	12(13.6)
11	My chemistry teacher‘s style of teaching organic chemistry nomenclature lacks personal touch	11(12.5)	13(14.8)	35(39.8)	17(19.3)	12(13.6)
12	I have a positive attitude towards learning of organic chemistry nomenclature	27(30.7)	27(30.7)	19(21.6)	11(12.5)	4 (4.5)

Key: SA = Strongly Agree, **A**= Agree, **NS** =Not Sure, **D**= Disagree, **SD**= Strongly Disagree

From Table 6, 39 students representing 44.3% of the total respondents agreed that organic chemistry nomenclature is too abstract to learn, 26 students representing 29.5% indicated that they were not sure if it is too abstract to learn while 23 students representing 26.2% disagreed that organic chemistry nomenclature is too abstract to learn. Taber (2002) suggested that chemistry curricula mostly integrate many abstract concepts most of which though essential to further learning in both chemistry and other sciences, most students find difficult to comprehend.

Thirty-two (32) students representing 36.7% of the total respondents agreed that their Chemistry teacher makes learning of organic chemistry nomenclature uninteresting while 25 students representing 28.4% indicated that they were not sure. Another 29 students representing 32% of the total respondents disagreed that their Chemistry teacher makes learning of organic chemistry nomenclature uninteresting. Also,35.2% of students representing 31 out of a total of 88 students agreed that they are always excited during organic chemistry nomenclature lessons. Furthermore,29.5% of the students also disagreed with this while 35.2% of the students stated that they were not sure. Fourteen (14) students representing 15.9 % of the total respondents agreed that they have a negative attitude towards organic chemistry nomenclature lessons, 16 students representing 18.2% of the respondents stated that they were not sure while a majority of the students representing 65.4% of the total respondents disagreed with this statement. The aforementioned results disagree with Salta and Tzourgraki (2004) who suggested that poor performance in the subject has been attributed to students' negative attitude towards chemistry. About 31.8 % of students agreed that they enjoy learning organic chemistry nomenclature as compared to other topics in Chemistry, while 37.5 % of respondents disagreed with this statement and 30.7% stated that they were not sure. Likewise 42.1% of students indicated that their chemistry teacher makes learning of organic chemistry nomenclature lessons interesting and fun while 28.4% of students indicated that they are not sure and 31% of students disagreed with this statement.

Also,30.7% of respondents (students) agreed that they understand organic chemistry nomenclature lessons with less effort while 32% of the respondents disagreed with this statement. Thirty-six percent (36%) of them indicated that they were not sure. Undoubtedly, Majority of the respondents 37.5% of the total respondents agreed that organic chemistry nomenclature is interesting but difficult, About, 30.7% of students indicated that they were not sure while 31.9% of the students disagreed with this statement. Erduran and Scerri (2003) for instance stated emphatically that learning chemistry poses a challenge to a majority of students, particularly in its sub-disciplines which include inorganic chemistry, organic chemistry and physical chemistry. Sirhan (2007) states chemistry is often regarded as a difficult subject, an observation that sometimes repels students from continuing with their studies in chemistry.

Furthermore,37.5 % of students agreed that their Chemistry teacher‘s method of teaching is more innovative and helps them to understand organic chemistry nomenclature easily while 21.8% of students disagreed with the statement and 30.7% of them stated that they are not sure. Also, 27.3% of respondents stated that their chemistry teacher‘s style of teaching lacks personal touch while 39.8% said that they were not sure, Again, 21.9% of respondents indicated their disagreement with that statement. Lastly, on students‘ having positive attitude towards the learning of organic chemistry nomenclature, surprisingly,61.4 % of students agreed with this statement, 21.6% also stated that they are not sure while 17% of respondents disagreed with the statement.

4.3 Research question 2: What is the effect of digital media on students' academic performance in expressing organic chemistry nomenclature?

The null hypothesis associated with this research question is tested in Table 7.

Table 7: Difference in The Academic Performance of the Experimental and Control Groups of Students Before the Treatment

Groups	Number of students	Mean (Max =100)	Mean Diff.	P-Value	Remarks
Experimental	55	37.93			
Control	48	38.02	0.09		Not significant
				0.483	

$P > 0.05$ = Not Significant, $P < 0.05$ = Significant

Table 7 shows the results of the pre-test scores from the experimental and control group. The mean values of 37.93 and 38.02 of the experimental and control group respectively indicated that a lot of students' scores centred around 38.00 and this confirms that students' academic performance in organic chemistry nomenclature is very low. A mean difference of 0.09 was obtained. Generally, the poor performance in the subject has been attributed to among other factors, students' attitude towards chemistry (Dhindsa & Chung, 2003; Olatoye, 2002; Salta & Tzougraki, 2004), teachers' attitude towards students' abilities in chemistry (Abudu & Gbadamosi, 2014; Ogembo, 2012), inadequate teaching and learning resources (Twoli, 2006), and poor teaching pedagogy (Sirhan, 2007).

To determine if there is a statistically significant difference between the pretest scores of the experimental and control group of students, a Z-test was used and the results are presented in Table 8. From Table 7, there is no statistically significant difference between the pre-test scores of the control and experimental group as a p-value of 0.483 was obtained which is greater than the significant alpha value (0.05). This means that the academic performance levels of the control and experimental groups of students are of the same level, therefore, hypothesis Ho1 cannot be rejected but should be accepted.

Table 8 presents results on the differences in the academic performance of the experimental and control group of students after treatment

Table 8: Difference in The Academic Performance of The Experimental and Control Group of Students After the Treatment

Groups	**Number of students**	**Mean (Max =100)**	**Mean Difference**	**Standard deviation**	**P-Value**	**Effect size**	**Remarks**
Experimental	55	52.86	7.78	12.91	0.00035	0.67	Significant
Control	48	45.08		10.34			

P > 0.05 = Not Significant, P< 0.05 = Significant

Table 8 shows the results of the post-test scores from the experimental and control group. The experimental group obtained a mean score of 52.86 while the control group obtained a mean score of 45.08. The mean scores of both groups increased, especially the experimental group after the treatment. The mean difference between the two groups was 7.78. The standard deviation of the experimental group is 12.91 and the control was 10.34. The Z test was used to determine the statistically significant difference between the post-test scores of the experimental and control group and a p-value of 0.00035 which is lower than the significance level alpha (0.05) was obtained.

With this result, one should reject the null hypothesis Ho2. From Table 8, an effect size of 0.67 was obtained indicating that digital media has a medium effect on students‘ academic performance in organic chemistry nomenclature. Hence, digital media has proven to have a positive effect on students‘ academic performance in organic chemistry nomenclature and improved their level of understanding as well.

This is in line with the findings of ImpaCT2 (2001) which revealed that teachers in schools where students were taught English using digital media platforms obtained higher mean scores for their students which was attributed to the fact that the use of digital media platforms in teaching and learning has a positive effect on attitude, interest, interaction and problem-solving skills that enables students to learn more independently. Other subjects in which digital media instruction has shown a positive impact include business management (Tanui, 2013).

The results also agree with the findings of Emron and Dhindsa (2010), which showed that the integration of interactive whiteboard technology significantly enhanced secondary school science instruction. Yusuf and Afolabi (2010) in a study on the effect of digital media instruction (DMI) on secondary school student's performance in biology confirmed that the performance of students exposed to digital media instruction either individually or collectively was better than their colleagues exposed to the conventional classroom teaching and learnings. Siddiqui and Khatoon (2013) maintain that digital media instruction and its various modes can support new inquiry-based approaches to science instruction and field learning experiences. Digital media instruction platforms allow students to visualize and explore scientific phenomena.

Digital media instruction platforms also strengthen the teaching of chemistry generally (Ezeudu & Ezinwanne, 2013; Garanga, Amadalo, Wanyonyi, Akwee & Twoli, 2012).

Henriques (2002)and Dori and Barak (2000) as reported in Kargiban and Siraj (2009), maintain that the use of digital media improves learning of the subject and creates an interactive learning atmosphere resulting in students' improved performance a proposition buttressed by Akcay, Feyzolu and Tuysuz (2003) as well as Ezeudu and Ezinwanne (2013. Other benefits include increased attendance, motivation, interest and cooperation among students. Bhukuvhani, Zezekwa and Susuma (2011) citing Funkhouser (1993) reported significantly higher test scores for students who used digital media-related instructional platforms than students who did not mean that the learning platforms or tools also affected their problem-solving skills or abilities.

4.4 Research question 3: What are the differential effects of digital media on male and female experimental group students' academic performance in expressing organic chemistry nomenclature?

Table 9 presents results on the male and female experimental group of students' academic performance in organic chemistry nomenclature

Table 9: Differential effects of digital media on the male and female students' academic performance in expressing organic chemistry nomenclature

Experimental Group	Number of students	Mean (Max=100)	Mean Difference	Standard deviation	P-Value	Effect size	Remarks
Male	31	52.81	0.11	14.22	0.487	0.0086	Not significant
Female	24	52.92		11.30			

P > 0.05 = Not Significant, P< 0.05 = Significant

Table 9 shows the results of the posttest scores of the male and female students of the experimental group. The male students obtained a mean score of 52.81 while the female students obtained a mean score of 52.92. The mean difference between the two groups is 0.11. The standard deviation of the male group is 14.22 and the female is 11.30. Z-test was used to determine the statistically significant difference between the post-test scores of the male and female students of the experimental group and a p-value of 0.487 which is greater than the significance level alpha (0.05) was obtained so one should accept the null hypothesis Ho3, as there is no statistically significant difference between the mean post-test scores of the male and female experimental group of students. Again, a negligible effect size of value 0.0086 was obtained which is too small, reaffirming that there is no significant difference between two the groups. From the result of Table 10, there is no differential effect of digital media on male and female students‘ academic performance in organic chemistry nomenclature.

The findings in table 9 support Uduosoro's (2011) findings, which indicated that students' academic performance is unaffected by their gender, regardless of whether they are male or female and also the findings of Igboegwu and Okonkwo (2012), Busari et al. (2016) and Samuel and Okonkwo (2020) who revealed that there was no statistically significant gender difference in the academic performance of students in chemistry. On the other hand, Ekundayo‘s (2022) findings revealed that female students performed better than their male counterparts in the experimental group (that is when they are both taught with DMI). Jegede (2007), Nbina and Wagbara (2012), and Julius (2018) found that females achieve better than males. This is, however, in contradiction to Okereke and Onwukwe (2011), Ezeudu and Obi (2013), Achor, Kurumeh and Orokpo (2012) and Ukozor (2011) who found out that male students achieved better than their female counterparts.

4.5 Research question 4.: What are the views of students on the use of digital media for instructions in organic chemistry nomenclature?

The students‘ responses to items on their views on the use of digital media for instruction in organic chemistry nomenclature are shown in Table 10.

Table 10: Views of students on the use of digital media for instructions in organic chemistry nomenclature

S/N	Statement	SA F (%)	A F (%)	N S F (%)	D F (%)	SD F (%)
1	Digital media makes organic chemisty nomenclature creative	15(27.3)	22(40.0)	15(27.3)	2(3.6)	1(1.8)
2	Digital media facilitates 3-dimension visualization of organic compounds	6(10.9)	19(34.5)	26(47.3)	2(3.6)	2(3.6)
3	Does not ensure the availability of teachers throughout the classroom	4(7.3)	15(27.3)	24(43.6)	9(16.4)	3(5.5)
4	Digital media is an excellent collaborative tool for learning organic chemistry nomenclature of organic compounds	4 (7.3)	15(27.3)	22(40)	12(21.8)	2(3.6)
5	Organic chemistry nomenclature via digital media is abstract to me	2(3.6)	13(23.6)	24(43.6)	(21.8)	4(7.3)
6	Learning organic chemistry nomenclature digital media is complicated	3(5.5)	14.(25.5)	29(52.7)	8 (14.5)	1 (1.8)
7	Digital media enhances students‘ involvement in organic chemistry nomenclature lessons	7(12.7)	13(23.6)	17(30.9)	14(25.5)	4 (7.3)
8	It is difficult to collaborate with other students via Digital Media	5(9.1)	19(34.5)	12(21.8)	12(21.8)	7(12.7)
9	I do not feel comfortable discussing nomenclature via Digital Media	4(7.3)	14(25.5)	22(40.0)	11(20.0)	4(7.3)
10	Digital Media helps me to share my view during organic chemistry nomenclature	8(14.5)	9(16.4)	21(38.2)	16(29.1)	1(1.8)
11	I do not recommend teachers use digital media to instruct nomenclature of organic compounds in class.	13(23.6)	6(10.9)	16(29.1)	8(14.5)	12(21.8)
12	Digital Media is an effective teaching tool for large class sizes	6(10.9)	9(16.4)	19(34.5)	12(21.8)	9(16.4)

Key : SA = Strongly Agree, **A**= Agree, **NS** =Not Sure, **D**= Disagree, **SD**= Strongly Disagree
Source: Field data, 2022

From Table 10, majority of respondents representing 67.3% indicated or agreed that digital media makes organic chemistry nomenclature creative, 27% indicated that they are not sure while 5.4% of respondents disagreed with this statement. Also,45.4% of respondents indicated that digital media facilitates 3-dimension visualization of organic compounds and this agrees with that of Yushau et al. (2003), whose findings reported that visual-supporting tools improve students‘ concept formation more than illustrations in books, an assertion also supported by Shaw (2006). Likewise, 47.3% of respondents were not sure while 7.2% of respondents disagreed with this statement. About 34.6% of respondents agreed with the statement that digital media does not ensure the availability of teachers throughout the classroom and 43.6% of respondents also indicated that they were not sure while 21.9% of respondents disagreed with the statement. About 34.6% of respondents also agreed that digital media is an excellent collaborative tool for learning the organic chemistry nomenclature of organic compounds,40% of the respondents indicated that they were not sure while 25.4% of respondents disagreed with this statement.

About 37.2% of respondents agreed that organic chemistry nomenclature via digital media is abstract to them and 43.6% of respondents indicated that they were not sure. Furthermore, 29.1% of respondents disagreed with this statement and this is in line with Linn et al. (2010), who observed that digital media platforms can help students link abstract representations of scientific phenomena cognitively. Cotton (1991) found out that digital media instruction (DMI) improves concept formation exponentially with students learning as much as 45% quicker and possessing better retentive memory leading to more positive interest and performance than colleagues who were taught through conventional methods of instruction. About 31% of respondents agreed that learning organic chemistry nomenclature is complicated while 52.7% of respondents indicated that they were not sure of this statement while 16.3% of respondents disagreed with this statement. Also, 36.3% of respondents indicated that digital media enhances students' involvement in organic chemistry nomenclature lessons , 30.9% of respondents were uncertain and 32.8% of respondents disagreed with this statement. Also, 43.6% of respondents agreed with the statement that it is difficult to collaborate with other students via digital media,21.8 % of respondents also indicated that they are not sure while 34.5% of respondents disagreed with this statement.32.8% of respondents indicated that they feel comfortable discussing nomenclature via digital media while 40% of respondents indicated that they are not sure while 27.3% of respondents disagreeing to this statement.

About 30.4% of respondents agreed that digital media help them share their view during organic chemistry nomenclature lessons, 38.2% of respondents also stated that they are not sure while 30.9% of respondents disagreed with this statement. About 34.3% of respondents agreed with the statement that they do not recommend teachers to use digital media to instruct nomenclature of organic compounds in class, 29.1% of respondents also stated that they were not sure. About 36.2 % of respondents disagreed with this statement and this agrees with Anderson (2002) and Gyongyosi (2005) who also stated emphatically that the integration of digital media instruction (DMI) in the content delivery of organic chemistry is best placed for solving the pedagogy-based problems that teachers and students face in the mastery of concepts in the topic and by extension of the subject. Digital media is an effective teaching tool for large class sizes according to 27.8% of the respondents,34.5% of respondents also stated that they were not sure while 38.2% of respondents disagreed with this statement.

In summary, a significant majority (67.3%) of respondents agree that digital media enhances the creativity of organic chemistry nomenclature. Additionally, many respondents (45.4%) find digital media beneficial in visualizing 3D organic compounds. However, there are mixed opinions about its effectiveness in ensuring teacher availability (34.6% agree), its being an excellent collaborative learning tool (34.6% agree), and its abstractness (37.2% agree). Respondents also showed divided views on the complexity of learning (31% agree), students' involvement (36.3% agree), and the ease of collaboration (43.6% agree). Interestingly, despite previous research supporting digital media instruction (DMI), some respondents (34.3%) do not recommend using it for organic chemistry nomenclature.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.0 Overview

This chapter contains a summary of findings, conclusions, recommendations and suggestions offered to improve upon the teaching and learning of organic chemistry nomenclature.

5.1 Summary of major findings

This research aimed at investigating students‘ conception of organic chemistry nomenclature, examining the effects of digital media instruction on students‘ academic performance and determining their views of digital media in teaching organic chemistry nomenclature. The findings of this study are summarised as follows:

1. Many students find organic chemistry nomenclature abstract and challenging.
2. Some students believe their Chemistry teacher makes learning uninteresting, impacting their interest in the subject.
3. A majority of students have a positive attitude toward learning organic chemistry nomenclature.
4. Students' academic performance in organic chemistry nomenclature is very low, with mean scores centered around 38.00.
5. There is no statistically significant difference between the pre-test scores of the experimental and control groups, indicating similar academic performance levels.
6. Digital media had a significant positive impact on students' academic performance in organic chemistry nomenclature.
7. These results are consistent with prior research indicating the effectiveness of digital media in education.

8. The study revealed that there was no significant difference in academic performance between male and female students who used digital media for learning organic chemistry nomenclature, consistent with prior research on the topic.
9. Most respondents believe digital media enhances creativity in learning organic chemistry nomenclature (67.3%).
10. Many respondents see the benefit of 3D visualization with digital media (45.4%).
11. There are mixed opinions on digital media's effectiveness in areas like teacher availability, collaboration, and its abstractness in teaching organic chemistry nomenclature.

5.2 Conclusion

Based on the findings of this study, digital media has a positive effect on students‘ conceptual understanding, improves their academic performance, encourages their participation, and increases creativity during teaching and learning. Also, digital media is not gender biased according to the findings from the study and students have a positive view of this form of instruction.

5.3 Recommendations

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

1. Chemistry teachers in Ghana should place students at the centre of the teaching and learning process to enable them to be actively involved in the lesson.
2. Science teachers especially chemistry teachers in Ghana should adopt the DMI approach instead of the conventional teaching approach in teaching chemistry concepts.

3. All science teachers in Ghana should be given special training in the effective utilization of computers and other technologies in teaching chemistry concepts.
4. Regular in-service training should be organised for chemistry teachers in Ghana to update their knowledge on the importance of varying their instructional methodologies to yield a positive result.
5. Schools in Ghana should take initiative to provide ICT tools and devices needed to implement the Digital media instructional approach.
6. Prompt feedback should also as much as possible be given to science students in Ghana after every work done to enable them to know their strengths and weaknesses and work on them.
7. The curriculum in Ghana should emphasize more on the use of digital media instructional approach to improve students' manipulative and inquiry skills which are necessary to the teaching and learning of science. Science students in Ghana should not be given only theoretical assignments, but also practical ones to enhance their understanding

5.4 Suggestions for Further Studies

Based on this research findings, it is suggested that further research be undertaken in the following areas:

i. A comparative study of the effects of digital media instruction on the concept of Organic chemistry nomenclature in public and private senior high schools in the Central Region of Ghana should be conducted.

ii. A cross sectional study on the effects of digital media instruction on the teaching and learning of organic chemistry nomenclature should be conducted in the Public senior high schools in the Central Region of Ghana.

iii. A comparative study of the effects of digital media instruction on the teaching and learning of organic chemistry nomenclature in rural and urban districts in Ghana should be conducted.

iv. A study on the effects of digital media instruction on the performance of male and female senior high school chemistry students should be conducted in selected institutions in the Central Region of Ghana.

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APPENDIX A

PRE-TEST: ACHIEVEMENT TEST ON IUPAC NOMENCLATURE OF ORGANIC COMPOUNDS

SECTION A

Biographic Data   Time: One hour

Gender: Male ☐   Female ☐

Age: ☐ years

Name of School: ……………………………………………………………

This achievement test seeks to find out your understanding of IUPAC nomenclature of organic compounds. Please provide the responses in the spaces provided. Your performance will be used for research purposes only. Your identity is not required, and therefore you are to respond to the items to the best of your ability. You will be given **60** minutes to respond to the items after which your paper will be collected.

SECTION B

INSTRUCTION: **Each question is followed by four options lettered (a) to (d).** ***Tick the***

Correct option for each question. 20marks

1) Organic chemistry is defined as the branch of chemistry that studies

a) Hydrocarbon only (b) hydrocarbon and its derivatives c) carbon only (d) carbon and its compounds.

2) Catenation is the process where carbon atoms;

a) Combine with one another to form straight chains, branched chains or ring compounds containing many carbon atoms (b) combine with hydrogen, oxygen, nitrogen and halogens (c) form single, double or triple covalent bonds (d) combine with every element.

3) Hydrocarbons are compounds containing

a) Carbon and nitrogen only (b) carbon only (c) carbon, hydrogen and oxygen (d) carbon and hydrogen only.

4) The process of joining together small organic molecules to form a chain of repeating unit is referred to as (a) Cracking (b) isomerization (c) polymerization (d) aromatization.

5) The breaking of bigger hydrocarbons into smaller units is called a) cracking (b) reforming(c) dehydrogenation (d) hydrolysis.

6) Carbon has the ability to form four bonds with itself and other atoms because it is a) divalent (b) monovalent (c) trivalent (d) tetravalent.

7) A family of organic compounds which follows a regular structural pattern, in which each successive member differs in its molecular formula by a $-CH_2-$ group is known as

a) functional series (b) aromatic hydrocarbons (c) aliphatic hydrocarbons (d) homologous series.

8)…………………………… is an atom, a radical or a bond common to a homologous series and which determines the chemical properties of the series.

a) functional group (b) functional series (c) reaction series (d) group

9) …………is the existence of two or more compound with the same molecular formula but different structural formula is termed a) isotopy (b) polymerism (c) molecularism (d) isomerism.

10) Hydrocarbons can be grouped into;

a) Aliphatic hydrocarbons only (b) aliphatic and aromatic hydrocarbons (c) aromatic hydrocarbons only (d) cyclic hydrocarbons only.

11) One of these is an aromatic hydrocarbon?

a) $C_6H_5CH_3$ (b) $CH_3(CH_2)_4CH_3$ (c) $CH_2CH=CHCH_3$ (d) $CH_3CH_2CH_3$

12) The general molecular formula of alkenes is

a) C_nH_n (b) C_nH_{2n+2} (c) C_nH_{2n-1}(d) C_nH_{2n}.

13) The main chemical property that differentiates methane from ethene is

a) Hydrogenation (b) combustion reaction (c) substitution reaction (d) addition reaction.

14) The process involved in the conversion of ethyne to ethane is known as a) hydrogenation (b) dehydrogenation (c) hydration (d) isomerization.

15) The unsaturated nature of ethyne is due to the presence of

a) Two carbon atoms (b) single bonds (c) double bond (d) triple bond.

16) The reaction between ethene and bromine is called

a) Substitution (b) esterification (c) oxidation (d) addition

17) Which of the following statements is **not** correct about hydrocarbons?

a) They are all saturated compounds (b) They are organic compounds

c) They contain carbon and hydrogen d) They could be gases, liquids or solids

18) Which of the following statements is **wrong**?

Isomers of the same compound will a) contain the same types of atoms (b) contain the same number of atoms (c) not necessarily have the same physical or chemical properties. d) Have the same physical and chemical properties.

19) The two main types of Isomerism are

a) Structural and non-structural (b) structural and geometric (c) cis and trans (d) geometric and non-geometric

20) The IUPAC name of the organic compound $CH_3CH_2CHClCH_3$ is a) 3-chlorobutane (b) butan-3-chlorine (c) 1-chlorobutane d) 2-chlorobutane

SECTION 2

A. Write the correct **condensed and graphical** formulae for each of the following organic compounds:

1. Pentene

a. Condensed Formula b. Structural Formula

……………………………………… ………………………………………………

2. Hex-2-yne

a. Condensed Formula b. Structural Formula

…………………………………… …………………………………………

3. Butan-3-ol

a. Condensed Formula b. Structural Formula

………………………………….. …..……………………………………

4. Butanoic acid

a. Condensed Formula b. Structural Formula

…………………………………… ….…………………………………

5. Tetrachloromethane.

a. Condensed Formula b. Structural Formula

………………………………… ………..………………………………

APPENDIX B

POST TEST : ACHIEVEMENT TEST ON IUPAC NOMENCLATURE OF ORGANIC COMPOUNDS

SECTION A

Biographic Data Time; one hour

Gender: Male ☐ Female ☐

Age: ☐ years

Name of School: ……………………………………………………………

This achievement test seeks to find out your understanding of IUPAC nomenclature of organic compounds. Please provide the responses in the spaces provided. Your performance will be used for research purposes only. Your identity is not required, and therefore you are to respond to the items to the best of your ability. You will be given **60** minutes to respond to the items after which your paper will be collected.

SECTION B

1.What is hydrocarbon? (1mk)

b. Consider the compounds listed below;

C_2H_4, C_2H_6, CH_3COOH, CH_3COOCH_3 and $CH_2=CHCH_3$.

Select the one(s) which;

(i) belongs to the same homologous series (1mk)

(ii) is likely to have a pleasant fruity smell. (1mk) (5mks)

(iii) are not hydrocarbons (1mk)

(iv)will undergo polymerization (1mk)

2.Give the IUPAC names of the following compounds

(i) CCl_4

(ii) C_2H_5OH

(iii) CH_3COOH (5mks)

(iv) CH_3COOCH_3

(v) $CH_2=CHCH_3$

3.Draw the structure of the following compounds

(a) Ethanoic acid

(b) 2,2 dimethyl butane

(c) 3-methyl pent-2-ene (5mks)

(d) 2-methyl butan-2-ol

(e) Ethanol

(4) What is functional group? (2mks)

b. Draw the structure of each of the following functional groups

(i) Alkynes

(ii) Alkanol (3mks)

(iii) organic acid

(5) What is unsaturated hydrocarbon? (2mks)

(i) Give two examples of unsaturated hydrocarbons (2mks)

(ii) write down the structural formula for 2-methyl propane (1mk)

(6) State the general molecular formula of each of the families of organic compounds.

(a) alkanes

(b) alkenes (5mks)

© alkynes

(d) alkanols

APPENDIX C

QUESTIONNAIRE FOR STUDENTS TO ASSESS THE CONCEPTIONS OF STUDENTS ABOUT ORGANIC CHEMISTRY NOMENCLATURE LESSONS

Your input in this study will be highly appreciated. All information provided is strictly confidential and for academic purposes only.

SECTION A

BIODATA

1. Name of School: ……………………………………………………….
2. Sex: Male [ ] Female [ ]
3. Class: Form 1 [ ] Form 2 [ ] Form 3 [ ]

SECTION B

Kindly indicate your level of agreement/ disagreement with the statements below.

SA- strongly agree **A**- Agree **N**-Not Sure **DA**-disagree **SD**- strongly disagree

S/N	STATEMENT	S/A	A	N	D	S/D
1	Organic chemistry nomenclature is too abstract to learn.					
2	My chemistry teacher makes learning of organic chemistry nomenclature uninteresting					
3	I am always excited during organic chemistry nomenclature lessons					
4	I have negative attitude towards organic chemistry nomenclature lessons.					
5	I do not enjoy learning organic chemistry nomenclature as compared to other topics in chemistry.					
6	My chemistry teacher makes learning of organic chemistry nomenclature interesting and fun.					
7	I understand organic chemistry nomenclature lessons with less effort.					
8	Organic chemistry nomenclature lessons are interesting but difficult					
9	Organic chemistry nomenclature of compounds is easy and interesting					
10	My chemistry teacher‘s method of teaching is more innovative and helps me to understand organic chemistry nomenclature easily.					
11	My chemistry teacher‘s style of teaching organic chemistry nomenclature lacks personal touch.					
12	I have positive attitude towards learning of organic chemistry nomenclature.					

APPENDIX D

QUESTIONNAIRE FOR STUDENTS TO ASSESS THE VIEWS OF STUDENTS ON THE USE OF DIGITAL MEDIA IN ORGANIC CHEMISTRY NOMENCLATURE LESSONS

Your input in this study will be highly appreciated. Every information provided is strictly confidential and for academic purposes only.

SECTION A

BIODATA

1.Name of School: ……………………………………………………….

2.Sex: Male [ ] Female [ ]

3.Class: Form 1 [ ] Form 2 [ ] Form 3 [ ]

SECTION B

Kindly indicate your level of agreement/ disagreement with the statements below.

SA- strongly agree **A**- Agree **N**-Not Sure **DA**-disagree **SD**- strongly disagree

S /N	STATEMENT.	S/ A	A	N	D	S/D
1	Digital media makes instruction of organic chemistry nomenclature more creative.					
2	Digital media facilitate 3-dimension visualization of organic compounds.					
3	Digital media does not ensure the availability of the teacher throughout the classroom.					
4	Digital media is an excellent collaborative tool for learning nomenclature of organic compounds than conventional teaching.					
5	Organic chemistry nomenclature taught via digital media is abstract to me.					
6	Learning organic chemistry nomenclature via digital media is complicated.					
7	Digital media enhances student's involvement in organic chemistry nomenclature lessons.					
8	It is difficult to collaborate with other students via digital media.					
9	I do not feel comfortable discussing nomenclature of organic compounds with other students via digital media.					
10	Digital media helps me to share my views during organic chemistry nomenclature lessons.					
11	I do not recommend teachers to use digital media to instruct nomenclature of organic compounds in class					
12	Digital media is an effective teaching tool for large class sizes.					