ANALYSIS OF ANALOGIES USED IN SOLVING STUDENTS' MISCONCEPTIONS IN SOME SELECTED SENIOR SECONDARY SCHOOL CHEMISTRY TEXTBOOKS IN NIGERIA

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A RESEARCH PROJECT SUBMITTED TO THE DEPARTMENT OF SCIENCE EDUCATION, FACULTY OF EDUCATION, UNIVERSITY OF ILORIN, ILORIN, NIGERIA

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF SCIENCE EDUCATION [B.Sc. (Ed.)] DEGREE IN CHEMISTRY

NOVEMBER, 2022

DECLARATION

I declare that the project, "Analysis of Analogies Used in Solving Students' Misconceptions in Some Selected Senior Secondary School Chemistry Textbooks in Nigeria" is my own work and has not been previously submitted by me or any person for any course or qualification in this or any other tertiary institution.

I also declare that as far as I am aware, all cited works have been acknowledged and referenced.

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CERTIFICATION

This is to certify that this study was carried out by **OGUNLAKIN, Grace Odunayo** (17/25PB090). It has been read and approved as meeting part of the requirements of the Department of Science Education, Faculty of Education, University of Ilorin, Ilorin, Nigeria for the award of Bachelor of Science Education [B.Sc. (Ed.)] Degree.

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DEDICATION

This project work is dedicated to God the Sustainer who is ever faithful and the best confidant that brought this work into completion. May His Holy name be glorified till eternity (Amen).

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ABSTRACT

The importance of the use of analogies in fostering better understanding of abstract scientific concepts cannot be over-emphasized in the field of science education. Textbooks like every other instructional material occupy a significant place in the teaching-learning process. This study was carried out to identify and analyze analogies used in solving students' misconceptions related to organic chemistry in some selected textbooks used in Nigerian secondary schools.

In this study, five selected Chemistry textbooks were examined using descriptive analysis method to determine the types of analogies used in the textbooks. Analogies identified were classified in line with a classification scheme that was modified by Olayemi (2021). Criteria such as Presentation format, Nature of Shared Attributes, Position of analogue to the target, Abstraction, Level of enrichment, Use of the term analogy and Limitation were examined. The selected analogies in the textbooks were taken to the researcher's supervisor for scrutiny and approval. The pro forma developed were given to experts in the field of science education and physical science (two chemistry lecturers and one chemistry teacher) to determine the relevance and appropriateness. Four research questions were raised and answered. Data gathered were analyzed using frequency counts, percentages and bar chart to show the degree of relevance and appropriateness of the identified analogies by the raters.

Based on the analysis, a total number of 117 analogies related to organic chemistry concept were identified in the five Chemistry textbooks. New School Chemistry for Senior

Secondary Schools had the highest number of analogies (38), while Lamlad's SSCE & UTME Chemistry had the least number (17). In conclusion, the identified analogies were mainly Verbal (58.97%), Functional (39.32%), Simple (43.59%) and Concrete-Abstract (78.63%). Only one author described limitation for one analogy and none of the authors stated that they were using analogies. The relevancy and appropriateness of the identified analogies were determined by two chemistry lecturers and one chemistry teacher. All the experts rated the analogies above average which is substantial enough for the analogies to be relevant and appropriate.

Based on the findings, the following recommendations were developed. Textbooks authors should use analogies effectively in their texts by using more pictorial analogies which tends to arouse students' interest in sciences, since what is seen stick more to the memory than what is said or read. Authors should include more of structural analogies as this helps to concretize abstract concepts and bring about deeper understanding. Furthermore, the authors should include more of enriched or extended analogies in their text, rather than simply using simple analogies. Authors could also precede the analogies with the words like: analogous, analog etc. and also state the limitations of the analogies used since analogies are known to break down at a point and this will go a long way in preventing students' misconceptions.

CHAPTER ONE

INTRODUCTION

Background to the problem

Science is a continuing effort to discover and increase knowledge through research. Scientists make observations, record measurable data related to their observations, and analyze the information at hand to construct theoretical explanations of the phenomenon involved. The word Science comes from Latin word “Scientia” meaning “knowledge” and in the broadest sense it is any systematic knowledge-base or prescriptive practice capable of resulting in prediction. Science is a great enterprise which nations depend on to advance technologically. Scientific knowledge allows us to develop new technologies, solve practical problems and make informed decisions. Therefore, science is receiving much emphasis in education because of its significance and relevance to life and the society. The relevance of science and technology to humans and the world at large has impacted different areas of human endeavour such as medicine, communication, transportation, agriculture, education, and so forth.

Science has been defined by many scholars depending on the perspective from which they see it. Abimbola (2013) defined Science as a body of knowledge, a way of investigating and thinking in the pursuit of an understanding of nature. Science has also been defined by Bradford and Hamer (2022) as a systematic and logical approach to discovering how things in the universe work and also the body of knowledge accumulated through the discoveries about all the things in the universe. Science aims for measurable

results through testing and analysis. Science is based on fact, not opinion or preferences (Bradford & Hamer, 2022). Science is an essential element in daily life. It makes our life easier, helps organize our daily activities and help our work to be done faster. Science is one of the most important channels of knowledge. It has specific role, as well as a variety of functions for the benefit of our society: creating new knowledge, improving education and increasing the quality of our lives.

Gero (2011) asserted that most of the educational objectives in Nigeria can be achieved through effective science education. Hence, science education is given priority because it will help in providing the essential manpower for the development of the country in areas such as Agriculture, extraction and processing of mineral resources, industrial production of consumer goods, Medicine and Pharmacy. The need for effective Chemistry education in Nigeria appears very crucial and therefore, demands considerable attention. For instance, Chemical Technologists and Technical workers are needed in all those Chemistry-related fields mentioned above. These fields cannot be effectively studied without Chemistry as it serves as pre-requisite to them. So, these aspects of the importance of Chemistry explain why schools, governments, students and parents are worried over students' poor achievement in Chemistry in Senior School Certificate Examination.

Science subjects like Biology, Chemistry, Physics, Mathematics and so forth are taught to students in Senior Secondary Schools. Chemistry is a branch of natural science that deals with the composition and constitution of substances and the changes they undergo as a consequence of alterations in the constitution of their molecules. Chemistry

as a branch of science that is rational and mathematical discipline where certain measured and controlled inputs lead to certain predictable outputs has become one of the most important disciplines in the school curriculum.

Chemistry is the scientific study of the structure of substances, how they react when combined or in contact with one another and how they behave under different conditions (Hornby, 2015). Science in general and Chemistry in particular plays a significant role in the economic development of a nation. Chemistry is an incredibly fascinating field of study because it is so fundamental to our world; chemistry plays a role in everyone's lives and touches almost every aspect of our existence in some way. Chemistry is essential for meeting our basic needs of food, clothing, shelter, health, energy, and clean air, water, and soil. Thus, studying chemistry is useful in preparing us for the real world. For example, chemistry explains aspects of plant chemistry (botany), the formation of igneous rocks (geology), how atmospheric ozone is formed and how environmental pollutants are degraded (ecology), the synthesis and reactions of simple molecules in interstellar space (cosmochemistry), how medications work (pharmacology), and how to collect DNA evidence at a crime scene (forensics).

Chemistry is often referred to as the central science because it joins together physics and mathematics, biology and medicine, and the earth and environmental sciences. Knowledge of the nature of chemicals and chemical processes therefore provides insights into a variety of physical and biological phenomena. Knowing something about chemistry is worthwhile because it provides an excellent basis for understanding the physical

universe, we live in. For better or for worse, everything is chemical. Studying chemistry also puts one in an excellent position to choose from a wide variety of useful, interesting and rewarding careers. A person with a bachelor's level education in chemistry is well prepared to assume professional positions in industry, education, or public service. A chemistry degree also serves as an excellent foundation for advanced study in a number of related areas. Even in times when unemployment rates are high, the chemist remains one of the most highly sought after and employed scientists (UW-La Crosse, 2022).

In general, in chemistry study there are three levels that must be mastered, namely the level of macroscopic, microscopic and symbolic (Johnstone, 2000). At the microscopic and symbolic level is an abstract level because it is not visible to the see (Demircioglu & Demircioglu, 2013). Macroscopic representation is a chemical representation obtained through real observation of a phenomenon that can be seen and perceived by the five senses or in the form of daily experience. Microscopic representation is a chemical representation that explains the structure and process at the level of particles (atomic / molecular) of the macroscopic phenomena observed. Symbolic representations are qualitative and quantitative chemical representations such as chemical formulas, diagrams, picture, reaction equations, stoichiometry and mathematical calculations (Johnstone, 1993). All of the concepts must be integrated so that learning objectives can be achieved.

Despite the relative importance of Chemistry to human life as a central science, observations on students' academic achievement in science generally and Chemistry in particular over the years in the results of Senior Secondary Certificate Examination (SSCE)

conducted by West African Examinations Council (WAEC) revealed that a very few numbers of students perform better in Chemistry examination compared with other subjects. The situation has really attracted the interest and concern of teachers, researchers, psychologists, parents and school administrators in Nigeria. Akwara (2017) highlighted the general problems that could lead to students' massive failure in National Examination conducted in Nigeria by WASSCE, GCE, NABTEB, NECO and other exams. Some of the contributing problems include registration of underage student in exam, unsound teaching and tutor and examination malpractices. According to Ifedili and Ojogwu (2007) some of the contributing factors include teaching and learning methods, poor reference materials like textbooks, inadequate instructional facilities, students' lack of interest and motivation.

From Table 1, it can be observed that the performance of students in chemistry has been low; there was slight improvement in 2010 follow by decreased in performance in 2011 and 2012. While the performance increased in 2013 and decreased from 2014 to 2016. General Resume Of The Chief Examiners' Reports For The West African Senior School Certificate Examination For School Candidates (2019) reported candidates' weaknesses that result in poor performance in Chemistry which are; (i) differences between dehydrating agent and drying agent; (ii) the use of kinetic theory of matter to explain how solids change when heated; (iii) elemental analysis of organic compounds; (iv) the formation of the dipolar ion by amino acids under acidic and alkaline conditions; (v) how recrystallization is carried out in the laboratory.

Table 1

Candidates' Enrolment and performance in May/June WASSCE in Biology, Chemistry and Physics in Nigeria from year 2007 to 2016.

Year	Biology			Chemistry			Physics		
	Total Sat	Credit Passed (A1-C6)	% Pass	Total Sat	Credit Passed (A1-C6)	% Pass	Total Sat	Credit Passed (A1-C6)	% Pass
2007	1,238,163	413,211	33.37	424,747	196,063	46.16	409,449	180,797	44.16
2008	1,259,964	427,644	33.94	456,980	202,762	44.37	408,237	200,345	49.08
2009	1,259,964	453,928	33.87	456,980	203,365	43.49	444,236	222,722	50.14
2010	1,300,418	427,644	32.88	465,643	263.059	50.70	463,755	237,756	51.27
2011	1,505,199	579,432	38.50	565,692	280,280	49.54	563,161	360,096	63.94
2012	1,646,150	587,044	35.66	627,302	270,570	43.13	624,658	429,415	68.74
2013	1,648,363	852,717	51.73	639,296	462,517	72.34	637,023	297,988	46.77
2014	1,365,384	766,971	56.17	636,268	397,649	62.49	635,729	386,270	60.76
2015	1,390,234	798,246	57.42	680,357	412,323	60.60	684,124	410,543	60.01
2016	1,200,367	740,345	61.68	706,873	408,122	57.74	705,125	415,655	58.95

Source: Statistics section of the WAEC Office Yaba, Lagos (2017)

Teachers should therefore, understand and teach abstract and concrete concepts in chemistry in a way that will be understandable to the students by using right reference materials like textbooks that use literacy concepts like analogies to make concepts more

interesting. By so doing, this will positively influence students' performance. Textbooks are important teaching materials that serve as a source for student learning in order to realize the purpose of teaching. Textbooks are prepared for the purpose of enabling students to learn information regarding topics of a lesson in an ordered and systematic way by themselves (Olayemi, 2021).

Chemistry as a subject has many misconceptions as a result of students' preconception before learning. The term 'Misconception' is a belief or idea that is not based on correct information or that is not understood by people. Examples of students' misconceptions are; Mass/Volume/Weight/heaviness/size/density may be perceived as equivalent, objects float on water because they are lighter than water, Heat is not energy, gases do not have mass, air and oxygen are the same, particles of solids have no motion and so on. These misconceptions greatly affect their learning of chemistry especially at Senior Secondary School level which is the foundation for their advanced learning in higher institutions.

Therefore, many researchers have taking into consideration the use of analogies in solving students' misconceptions in chemistry. It is possible to identify incorrect prior knowledge preventing meaningful learning as misconceptions. Because understanding a chemical concept requires identification at both macroscopic and microscopic level, students may develop several misconceptions considering abstract concepts. A misconception is well-known as a barrier to students in learning science. Some topics in science learning are always giving misconception to students.

National Research Council (1997) stated that the primary role of misconceptions in science is a barrier for students to learn science because in many cases, misconceptions can detain students to develop correct ideas used as the initial insight for advanced learning. This is parallel with King (2010) who unveiled those misinterpretations found in the textbook of Earth Science influence students' understanding of a scientific text which makes them difficult to comprehend further information or knowledge as a reader. Besides, teachers may also experience misconception in teaching physics, chemistry, or biology topics which leads inevitably to students' misconceptions (Bektas, 2017; Moodley & Gaigher, 2019). In other words, misconception will interfere with the quality and quantity of science learning process and outcomes for both student and teacher.

In order to understand the use of analogies in solving misconceptions in chemistry, analogies need to be understood. Simply stated, an analogy is a process of identifying similarities between two concepts. The familiar concept is called the analog and the unfamiliar science concept is called the target (Glynn, 1991). Analogies are believed to aid student learning by providing visualisation of abstract concepts, by helping compare similarities of the students' real world with the new concepts, and by increasing students' motivation (Duit, 1991).

Chemistry concepts can be examined in two groups; as abstract and concrete ones. While concrete concepts are improved as a result of students' experiences, it is considerably challenging for students to perceive abstract concepts. Since chemistry includes abstract concepts largely, it is considered to be hard to comprehend by the

students. In fact, studies confirm this thought. On this particular issue, it is clearly stated that students present themselves in learning environment, having some sort of thoughts and acknowledgments which are scientifically incorrect by a majority. The false information or acknowledgments are called misconception. Furthermore, it is also indicated that it is too hard to eliminate such misconceptions via the traditional teaching methods. Since each student constructs his/her own knowledge, understanding and concepts in accordance with his/her ability and experience, what matters here is, if prior knowledge of student involves any misconceptions, there is need to identify and eliminate such misconceptions. In this context, researches on identification and then elimination of misconceptions by Musa & Ilknur (2019) make a significant contribution to the chemistry education.

Organic chemistry, a subdivision of chemistry has been found difficult by most students in senior secondary schools. Therefore, they score lesser in organic chemistry than other topics in chemistry. Efe and Augustine (2016) result on the study of analysis of misconceptions in organic chemistry among selected senior secondary school students revealed that students have misconception in organic chemistry. It was indicated that lack of awareness of misconception by students in chemistry may be contributing factor to students' poor academic performance in chemistry. Based on the findings, it was recommended among others that the teaching of organic chemistry should start as early as SS1 so as to allow full coverage of its content and hence familiarize the students with its components.

Textbooks are important sources of analogies, more than 90% of secondary school teachers use textbooks to organize and deliver instruction (Sendur, Toprak, & Sahin-Pekmez, 2011). The analogies in textbooks are freely used by students and teachers. The analogies in textbooks are usually used randomly and can be insufficient for students and this leads to misunderstanding for students most of the time. Consequently, it is important to analyze the textbooks which involve analogies used by teachers and students. Therefore, there is need to analyze the analogies used in solving students' misconceptions in Senior Secondary School chemistry textbooks.

Statement of the Problem

Over the years the performance of students in Chemistry has not been encouraging. The WAEC chief examiners annual reports have continued to highlight students' weaknesses in answering questions relating to difficult concepts in the areas such as kinetic theory of matter, recrystallization, chemical bonding and organic chemistry. This shows that organic chemistry in chemistry examination has been one topic that is difficult for candidates to answer due to its complexity and this has affected the whole performance of students. Therefore, there is need for teachers' strategies and materials such as textbooks with clear explanations that can relate the topic to students' everyday life so as to make it interesting and easy to learn.

Omiko (2017) reported that results of past West African Examination Council of students in chemistry causes a lot of concern among stakeholders in education. It is suspected that lack of proper understanding of chemistry concepts accounts for students'

low performance in the subject. The author identified the content areas in the chemistry curriculum at the secondary school level, which the students find difficult. Nowadays, one of the problems encounters in science and chemistry education is that students could not relate between basic concepts. According to Treagust and Chittleborough (2001); Thiele and Treagust (2010), One effective way to deal with this problem is to provide a bridge between new concepts and knowledge of what the students already know. This bridge could be provided by analogies. According to Sendur et al., (2011) study on analysis of analogies used in secondary chemistry textbooks. Analogies plays central role in supporting the understanding of complex concepts and topics. One of the main sources of analogies is textbooks and it was found that that the uses of the analogies were limited in both 9th and 10th grades chemistry textbooks.

Efe and Augustine (2016) result on the study of analysis of misconceptions in organic chemistry among selected senior secondary school students in Zaria Local Government Kaduna state, Nigeria revealed that students have misconception in organic chemistry. It was indicated that lack of awareness of misconception by students in chemistry may be contributing factor to students' poor academic performance in chemistry. The result of the study asserted that there was no significant difference between male or female students' misconception in organic chemistry and their academic performance. Therefore, the main source of the misconceptions could be from the textbooks used by the students and there is need to analyze analogies used to explained the concept of organic chemistry in the textbooks. These lead to the current research on analysis of analogies used

in solving students' misconception in some selected senior secondary school chemistry textbooks with focus on the topic; 'Organic Chemistry'.

Purpose of the study

This study identified and analyzed analogies related to Organic Chemistry that are used in solving students' misconceptions in some selected Senior Secondary School chemistry textbooks. Specifically, the study:

i. Analyzed by classifying the types analogies identified in the selected chemistry textbooks on Organic Chemistry.
ii. Assessed the relevance of the analogies to teaching and learning of Organic Chemistry in the selected Chemistry textbooks.
iii. Assessed the appropriateness of the analogies to teaching and learning of Organic Chemistry in the selected Chemistry textbooks.
iv. Rank the textbooks in terms of numbers of analogies used.

Research Questions

In this study, the following questions were answered:

i. What are the types of analogies used in the selected Chemistry Textbooks to explain Organic Chemistry?
ii. Are the analogies used in the selected Chemistry textbooks relevant in teaching and learning of Organic Chemistry?
iii. Are the analogies used in the selected Chemistry textbooks appropriate in teaching and learning of Organic Chemistry?

iv. How are the textbooks ranked according to the numbers of analogies used?

Scope of the study

This study focused on analysis of analogies related to Organic Chemistry that are used in solving students' misconceptions in Senior Secondary School Chemistry Textbooks. Three chemistry textbooks were selected purposively from Kwara State Ministry of Education and Human Capital Development 2021-2024 Approved List of Books for Senior Secondary Schools 1-3 and two other chemistry textbooks frequently used by senior secondary schools in Ilorin, Kwara State, Nigeria. The analogies were identified from the content of organic chemistry in each textbook.

Significance of the study

The outcome of this study would be of vast benefit to Students, Chemistry Teachers, Curriculum Planners, Ministry of Education, Teacher Training Institutions, Textbook Writers and Researchers.

The study would also be of benefit to Senior Secondary School students and students of higher institution by helping them to identify the analogies used in presenting the concepts of organic chemistry in Chemistry textbooks. Moreover, this study might provide a standard by which the students select chemistry textbooks in terms of the analogies used in explaining organic chemistry concepts.

The findings might help chemistry teachers to be aware of analogies in Chemistry textbooks as it presented basic information on the presentational format, analogy positions and level of enrichment of analogies used in Chemistry Textbooks. This study will increase

the awareness of teachers on the various misconceptions upheld by Senior Secondary School students who offer chemistry, by identifying such misconceptions and the impact of such misconceptions on students' understanding of chemistry. This study would challenge chemistry teachers to properly use analogies that correctly convene accurate understanding of chemistry to Senior Secondary School students. This research could equip chemistry teachers with improved and new strategies of solving students' misconception with the use of analogies in chemistry textbooks.

In addition to the above listed benefits, the findings might be of importance to the textbook authors, science teachers, teachers in training, school administrators and the curriculum developers to be aware of analogies in chemistry textbooks and maximizing the analogies to solve students' misconceptions in chemistry.

Future researchers may also use the findings of this study in getting related literature regarding this subject. Finally, it would also be of great value to tertiary institution students researching into similar area. The study would be significant to policymakers and policy implementers, as they could make use of the findings and recommendations of this study.

This study seeks to complement other studies that have looked into how to resolve problems encountered by students in understanding chemistry concepts by using analogies in solving students' misconceptions in chemistry and promote efficient teaching and learning process of chemistry as a subject in Senior Secondary Schools.

Clarification of Major Terms and Variables

The following clarifications and definitions are made in context to this present study:

Analysis: A process of critically looking into a concept or a process of separating into constituents' elements in order to study nature, function or meaning of a concept.

Analogy: A similarity between like features of two things on which a comparison may be based.

Misconception: It is an erroneous conception or mistaken notion.

Teacher: A person who teaches or instruct especially as a profession.

Student: A person formally engaged in learning, especially one enrolled in a school or college. It is also any person who studies, investigates or examines thoughtfully.

Chemistry: The science that deals with the composition and properties of substances and various elementary forms of matter.

Chemistry Textbooks: A formal manual of instruction in chemistry used in schools and colleges.

Organic Chemistry: This is the study of the structure, properties, composition, reactions and preparation of carbon-containing compounds.

Verbal: The analogy is presented in the text in a verbal format only.

Pictorial-verbal: The analogy is presented in a verbal format along with a picture of the analogue.

Structural: Analogue and target concepts in an analogy share similar attributes such as shape, size, color. etc.

Functional: Analogue and target concepts in an analogy share similar attributes such as function, behavior. etc.

Structural-functional: Analogue and target concepts in an analogy share both structural and functional attributes.

Embedded activator: The analogue concept is presented in the text with the target concept.

Post synthesizer: The analogue concept is presented in the text after the target concepts.

Advance organizer: The analogue concept is presented in the text before the target concept.

Concrete-concrete: Both the analogue and target concepts are of a concrete nature.

Abstract-abstract: Both the analogue and target concepts are of an abstract nature.

Concrete-abstract: The analogue concept is of a concrete nature but the target concept is abstract.

Simple: Only one similarity is underlined between the analogue and target concepts. An analogy is formed from a simple sentence with no details.

Enriched: Two similarity dimensions between the analogue and target concepts are underlined. An analogical statement is formed from sentences that are basic for analogies.

Extended: Three or more similarity dimensions between the analogue and target concepts are emphasized.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

In this chapter, literatures related to this study are reviewed under the following subheadings:

- Theoretical Framework of the study
- Objectives and Contents of Senior School Chemistry Curriculum in Nigeria
- Students' performance in Chemistry in West African Examinations Council (WAEC)
- Misconceptions in Senior Secondary School Chemistry Textbooks
- Concept of Organic Chemistry
- Analogies and students' misconceptions in Organic Chemistry
- How Analogies in Chemistry Textbooks influence Teaching and Learning
- Empirical studies on Analogies used in solving students' misconceptions in Senior Secondary School Chemistry Textbooks
- Appraisal of the Reviewed Literature

Theoretical Framework of the study

Glynn and Colleagues (Glynn, 1989) developed a Teaching with Analogies (TWA) model, with a particular focus on students' interpretation of textbooks. Glynn (1989) proposes the following steps for interpretation of analogies:

(1) Introduce the target domain

(2) Introduce the source domain

(3) Identify similar features among the domains

(4) Map the similar features explicitly

(5) Draw conclusions

(6) Identify where the analogy breaks down.

Learning is a process of conceptual change and pervasive concept that cut across all human endeavors, it is a lifelong process that starts from birth and continues till death. In education, there are many learning theories which include: Behaviourism, cognitivism, constructivism and social learning theories and so forth. The views and perceptions of these theories on knowledge construction and acquisition vary.

According to Ngwoke (2008) the behaviorists perceived learning as habit formation. On the other hand, the social learning theorists understand learning simply as imitation while the cognitive theorist view learning as change in perception that involves active mental processes. Besides, Bello and Abimbola (2012) stated that the newer idea of the cognitive psychologists about learning is that learning is an active internal process of construction where learners' prior knowledge plays a significant role in further conceptual learning. These theories are in support of the use of analogies in Chemistry because analogies compare the learners' prior knowledge to new and abstract concepts.

Objectives and Contents of Senior School Chemistry Curriculum in Nigeria

National Open University of Nigeria (2015) submitted that the science curriculum contains a body of scientific knowledge to be acquired by the students in order to function beyond the basic education level. Chemistry is a body of scientific knowledge concerned

with the study of structure, composition, properties and the reactive characteristics of matter.

The aim of chemistry curriculum is to acquire an understanding of major chemistry concepts and awareness of how these are connected with the areas of life, environment, industry and world at large while the specific objectives of senior secondary school chemistry curriculum was borne from the revised edition as stated by the Nigerian Educational Research and Development Council (NERDC, 2007) which were said to have been derived from national policy statements on education, which are to enable students to:

I. develop interest in the subject of chemistry
II. acquire basic theoretical and practical knowledge and skills
III. develop interest in science, technology and mathematics
IV. acquire basic STM knowledge and skills
V. develop reasonable level of competence in ICT applications that will engender entrepreneurial skills
VI. apply skills to meet societal needs of creating employment and wealth
VII. be positioned to take advantages of the numerous career opportunities offered by chemistry
VIII. be adequately prepared for further studies in chemistry

Content: selection, focus and organization

The organizers of chemistry curriculum put into consideration the major issues that shaped the development of nations globally, which as well influence world of knowledge. As such the selection of contents of chemistry curriculum is centred around four themes such as:

1. The chemical world
2. Chemistry and environment
3. Chemistry and industry and
4. Chemistry and life.

These themes are also spirally arranged through the three years of senior secondary chemistry learning and contain topics that reveal the level of coverage of the content. For example, in senior secondary I Chemistry, the first topic has its performance objectives to prompting: the identification of chemical industries in the learners' locality, explanation on how chemical industries have influenced learners' lives and national economies, description of environmental problems created by chemical industries and suggesting solutions to solve those problems. Equipped with these objectives, teachers will find the corresponding contents for achieving the objectives to involve types of chemical industries, importance to the individual, the nation and excursion to chemical industries.

The Nigerian Senior Secondary School (SSS) Chemistry Curriculum covers three classes, Senior Secondary classes 1 – 3 and was developed around four themes (which are: Chemistry and Industry, the Chemical World, Chemistry and Environment and the

Chemistry of Life. In selecting the contents, three major issues shaping the development of nations worldwide and influencing the world of knowledge today were identified. These are globalization, information/communication technology and entrepreneurship. The desire that Nigeria be identified with contemporary development worldwide has called for the organization of the contents of the curriculum around the four themes. Thus, the curriculum is packaged with content that leads to self-actualization by students. In addition, the curriculum content focuses on practical activities with emphasis on locally available materials. This is to imbue the learners with the spirit of inquiry. The curriculum, if effectively implemented, will enable the learner achieve his/her maximum potential in the subject of chemistry and its various applications. The major topics covered in four themes in the three classes are summarized in the table below.

Table 2

Summary of Nigerian SS1-3 chemistry syllabus

Theme/class	**SS1**	**SS2**	**SS3**
Chemistry and industry	Chemistry and industries.	Oxidation reduction (redox) reaction, Ionic theory, Electrolysis.	Petroleum or Crude Oil, Metal and their compound, Iron, Ethical, legal and social issues.
The chemical world	Introduction to chemistry, Particulate nature of matter, Symbols, formulae and equations, Chemical combination, Gas laws.	Periodic table, chemical reactions, Mass, volume relationships.	Quantitative and qualitative analysis.
Chemistry and environment	Standard separation techniques for mixtures, Acids, bases and salt, Water.	Acid-base reactions, Water, Air, Hydrogen, Oxygen, Halogens, Nitrogen, Sulphur.	Topics asterisked below are to be treated here to enable students prepare and write their examinations towards the end of the term. Actually, the term was left open and free.
The chemistry of life	Carbon and its compounds.	Hydrocarbons, Alkanols.	*Fats and oil, Soap and detergent, Giants molecules (Sugar, Starch and Proteins).

Students' performance in Chemistry in West African Examinations Council (WAEC)

Chemistry is vital in the science world, being a gateway to professions like Medicine, Pharmacy, Dentistry, Agriculture, Engineering, Biochemistry and host of others. However, Poor academic achievement of chemistry students is evident in Senior Secondary School Certificate Examination. Science educators are worried over poor performance of chemistry students in secondary schools as this does not augur well for science education programs at tertiary institutions of learning**.** Despite the relative importance of Chemistry, it is very disappointing to note that the performance in the subject at both internal and external examinations has remained constantly poor and the trend of students' performance has been on the decline. Some of the variables that may be responsible for these may include curriculum related variables, non-expository textbooks, teacher's method of teaching, student rate of understanding, attitude of students toward chemistry and organic chemistry as a topic in Senior Secondary School.

West African Examinations Council (WAEC) and National Examinations Council (NECO) are major examination bodies in Nigeria. Nigerian students obtain their Senior School Certificate by passing examinations administered by either the Western African Examinations Council (WAEC) or the National Examinations Council (NECO). Many universities have also begun to administer their own entrance examinations due to allegations that results in these external examinations have been manipulated. Factors affecting the academic performance of secondary school students in Chemistry are teaching

method in chemistry and Students' Attitude towards Teaching and Learning of Chemistry (Amoke, 2020).

Nbina (2012) investigated the poor performance of students in Chemistry. The researcher reported that the widespread poor performance and the negative attitudes towards chemistry of secondary school students have been largely ascribed to teaching problems. One of the recommendations made was the need for efficient and effective teachers who are professionally and academically qualified to promote Chemistry learning in schools.

The listed factors responsible for poor performance of students in Chemistry are: Lack of qualified teachers, Lack of incentive for teachers, Incompetent teacher, Teachers' absenteeism, Lack of interest, Lack of understanding, Poor background, Lack of consideration, Chemistry difficulty, many topics that isn't understood and Abstractness of chemistry. From the above report, it can be deduced that if teachers' lack knowledge of analogies and how to solve students' misconceptions, it can affect the teaching-learning process.

Despite the relative importance of Chemistry to human life as a central science, observations on students' academic achievement in science generally and Chemistry in particular over the years in the results of Senior Secondary Certificate Examination (SSCE) conducted by West African Examinations Council (WAEC) revealed that a very few numbers of students perform better in Chemistry examination compared with other subjects. The situation has really attracted the interest and concern of teachers, researchers,

psychologists, parents and school administrators in Nigeria. Akwara (2017) highlighted the general problems that could lead to students' massive failure in National Examination conducted in Nigeria by WASSCE, GCE, NABTEB, NECO and other exams. Some of the contributing problems include registration of underage student in exam, unsound teaching and tutor and examination malpractices. According to Ifedili and Ojogwu (2007) some of the contributing factors include teaching and learning methods, poor reference materials like textbooks, inadequate instructional facilities, students' lack of interest and motivation.

From Table 1, it can be observed that the performance of students in chemistry has been low; there was slight improvement in 2010 follow by decreased in performance in 2011 and 2012. While the performance increased in 2013 and decreased from 2014 to 2016.

General Resume Of The Chief Examiners' Reports For The West African Senior School Certificate Examination For School Candidates (2019) reported candidates' weaknesses that result in poor performance in Chemistry which are; (i) differences between dehydrating agent and drying agent; (ii) the use of kinetic theory of matter to explain how solids change when heated; (iii) elemental analysis of organic compounds; (iv) the formation of the dipolar ion by amino acids under acidic and alkaline conditions; (v) how recrystallization is carried out in the laboratory. In addition, the performance of candidates for these exams depended largely on adequate preparation done by both teachers and candidates equally with regards to an adequate mastery and coverage of the syllabus prescribed.

Misconceptions in Senior Secondary School Chemistry Textbooks

Students' misconceptions have been a major threat in general teaching-learning process at school. Students' misunderstandings and misconceptions not only in sciences but also other disciplines at all levels constitute a major problem of concern to science educators, scientific researchers, teachers, and students. Thus, it is not only crucial to uncover students' alternative conceptions of chemistry at secondary level but the change of their views, is the main challenge for science teachers. Misconceptions cover a large range of science concepts, so science educators in many countries are paying attention upon students' misconceptions on science concepts.

Many students have difficulty in learning science because much of their learning tends to involve memorization of facts in which newly learned materials is not related in ways that make sense to the learner. However, learning in science is not just adding new concepts to the knowledge, but it often requires realignment in thinking and construction of new ideas that may be in conflict with earlier ideas.

Additionally, research studies have consistently shown that students do not come to classroom with blank slates. In fact, students from the moment of birth infants need to make sense of their world. They construct their own understanding for how and why things behave as they do. So, long before they began formal schooling, children have made meaning of their everyday observations and, they will construct new knowledge on their previous experience. As accepted by many scientists, when these students' previous conceptions are different from the views of scientists, these differing frameworks affect

further learning negatively. It is thus, obvious that students use preexisting conceptions constructed from reflection on previous experiences to reason about newly presented science concepts, and to make sense of their instructional science experiences. Such preconceptions are often incorrect from a scientific viewpoint.

Some students' misconceptions are very resistant to instructional change and some students persist in giving answers consistent with their misconceptions even after large amounts of instruction. The research conducted by Musa and Ilknur (2019) with the objectives to examine misconceptions identified in literatures, to study what those misconceptions are and how they are eliminated in literatures. As a conclusion of this study, many misconceptions, particularly on dissolution, melting, solubility equilibrium, chemical equilibrium, ionic bond, covalent bond, double and triple bonds, hydrogen bond and its molecular geometry, activity, electrolyze and battery, have been identified in related literatures for each age group of students in chemistry education. Within the framework of another objective of the study, the methods to eliminate the misconceptions identified in the literatures are examined. Considering this, it is concluded that traditional teaching methods do not function appropriately to eliminate misconceptions; instead, methods based on the constructivist approach are preferred. The word "misconception" implies

- Students' mistaken answers to a particular situation.
- Students' ideas which cause mistaken answers about a particular situation.
- Students' beliefs about how the world works different than that of the scientists.

Misconceptions play a larger role in learning chemistry than simply producing inadequate explanations to questions. Students either consciously or subconsciously construct their concepts as explanations for the behavior, properties or theories they experience. They believe most of these explanations are correct because these explanations make sense in terms of their understanding of the behavior of the world around them. Faced with new information that differs from their established conception, a cognitive conflict arises, the students being put in position to either change their rather naive view into a scientifically accepted one (for this to happen, a conceptual change must be developed first) or, otherwise, to reject or ignore this new information simply because it seems wrong.

In science, there are often many ideas that are frequently misapprehended. This may be the result of students survive with making sense of abstract concepts. Also, since science is constantly changing to adapt to new discoveries and methods, some misconceptions may be due to old ideas or legends. Since the formation of new concepts is based on building on the foundation of old ones. Students are basically familiar with a number of relevant concepts as a result of their previous learning. The potentially present preconceptions about the world itself can be reflected in the chemistry lessons and can sometimes grow into misconceptions.

Misconceptions that stem from the teaching process are referred to as school-made misconceptions. Perhaps the most resistant to change are the misconceptions that students build in the early stages of their development. Some of the reasons for their occurrence could be traced to problems of the specific terminology and used wording, especially when

introducing the concepts of substances, the particles of which they consist, chemical symbols used for their representation and structure of compounds. Nelson (2003) focused on the many basic chemistry concepts that are difficult to teach because the definitions of these concepts given in textbooks either lack precision, or invoke ideas that beginners are not familiar with, and have to accept on trust. In this respect, the situation in many secondary textbooks is not very different. Thus, statements can be found in which a substance reacts with one or more particles (atoms, molecule, and ions). These statements may lead to either formation of new misconceptions or strengthening already existing ones.

Misconceptions play a larger role in learning chemistry than simply producing inadequate explanations to questions. Structure and naming of organic compounds is one of the basic in organic chemistry that student find difficult. Many students aren't able to comprehend this concept. Understanding how to name organic compounds and its structure is important in organic chemistry in order to comprehend their properties (physical and chemical). In addition, understanding structure and name of organic compounds requires some other topics such as carbon and its compound, hydrogen, and alcohols in which students have difficulty in understanding. As a result, they hold many misconceptions related to these concepts.

Thus, students' misconceptions should be identified. It is of utmost importance to identify the misconceptions of students in chemistry textbooks, confront the erroneous notions by applying appropriate intervention program(s) expecting that the misconceptions will eventually be eliminated, corrected and replaced with ones that are correct and stable.

Many students at all levels struggle to learn chemistry, but are often unsuccessful. One possible answer is that many students do not construct appropriate understandings of fundamental chemical concepts from the very beginning of their studies; therefore, they cannot fully understand the more advanced concepts that build upon the fundamentals.

Concept of Organic Chemistry

Organic chemistry, the subdivision of chemistry that deals with the structure, properties, and reactions of combinations that contain carbon, and these compounds are known as hydrocarbons since they contain both hydrogen and carbon atoms mainly. Organic chemistry has valuable importance in the daily life of every people worldwide and has many unforeseen potential benefits for our future due to its role of being applied in different manufactures. Organic chemistry is the building block for all living organisms; Organic chemistry is also the chemistry of carbon mixtures, excluding carbon oxides, and metal carbonyls, metallic carbonates, and other related compounds. Organic chemistry is also known as the chemistry of hydrocarbon and its derivatives.

A report by West Africa Examinations Council (WAEC) stated that many students do not attempt organic chemistry questions and few who try to do so, answer them poorly. Organic chemistry sometimes confuses and seems as difficulty for novice learners if misconceptions are not addressed effectively. The awareness of students' misconceptions in organic chemistry will contribute as a factor to improve students' academic achievement in chemistry and this will help chemistry teachers to pay attention to this and find solution.

There are still misconceptions about organic chemistry where it is sometimes taken as difficult to learn by secondary school students. Students' difficulties and misconceptions are most of the time about applying IUPAC rules in naming organic compounds which is at the symbolic level of learning chemical concepts, writing of the structural formulae of hydrocarbons and unsaturated hydrocarbon, distinguishing substitution and addition reactions, polymerization, differentiating aromatic compound from condensed structure formula, isomerism, representation and drawing of organic compounds, the properties of organic compounds, Aromaticity, classification of organic compounds, reaction mechanisms, functional groups. Efe and Augustine (2016) stated that Students' aversion to certain key concepts in chemistry is on the increase. Such concept includes hybridization, chain reaction, chemical equation, polymerization and even nomenclature of organic compounds.

Classification of Organic Compound

The numbers of organic compounds existing are so many that it might appear impossible to study organic chemistry. Fortunately, most of the compounds have similarities in structure (i.e., arrangement of carbon atoms in molecules of the compounds). This makes it possible to classify the compounds into three main groups for easier study. The classifications are:

a) Acyclic or aliphatic organic compounds.

b) Carbocyclic organic compounds.

c) Heterocyclic organic compounds.

I. Acyclic or aliphatic organic compounds: These are compounds containing straight or branched chain carbon atoms with no ring structures. Hydrocarbons are contained in this group.

II. Carbocyclic organic compounds: These can be sub-divided into two groups.

1. Benzenoid carbocyclic compounds.
2. Non- Benzenoid carbocyclic compounds.

Benzenoid carbocyclic compounds: They are called aromatic compounds containing ring chain carbon atoms based on benzene and derivatives of benzene.

Non- Benzenoid carbocyclic compounds: They are those containing ring chain carbon atoms but not based on benzene structure.

III. Heterocyclic organic compounds: These are organic compounds containing ring chain of more than one kind of atom, carbon inclusive.

Apart from classifying organic compounds into three main groups, it is also possible to classify them into smaller groups or families called homologous series based on the regular structural pattern exhibited by the members.

Homologous series may be defined as family of organic compounds which are structurally related and each member differs from the next by $–CH_2-$ group.

Functional group is an atom or groups of atoms common to members of a homologous series which determines the chemical properties of the series.

Hydrocarbons

Hydrocarbons are the simplest form of organic compounds containing carbon and hydrogen atoms only.

Classification of hydrocarbons

i. Alkanes
ii. Alkenes
iii. Alkynes
iv. Benzenes

Alkanes: Alkanes are straight or branched chain hydrocarbons in which all the adjacent carbon atoms in the molecules of the alkanes are joined by single bonds. In some alkanes, carbon atoms are joined to form rings and these compounds are called **Cycloalkanes**. Both alkanes and cycloalkanes are **saturated hydrocarbons**.

Saturated hydrocarbons: Saturated hydrocarbons are organic compounds in which all the adjacent carbon atoms in the molecules of the compounds are joined by single bond. It is noted from the above that alkanes are saturated hydrocarbon is an analogy in organic chemistry.

Alkenes: Alkenes are straight chain or branched chain hydrocarbons in which there exists a double bond between two adjacent carbon atoms in the molecules of the hydrocarbons.

Alkynes: Alkynes are straight chain or branched chain hydrocarbons in which there exists a triple bond between two adjacent carbon atoms in the molecules of the hydrocarbons. Both Alkenes and Alkynes are **unsaturated hydrocarbons**.

Unsaturated hydrocarbons: Unsaturated hydrocarbons are organic compounds containing only carbon and hydrogen atoms in which there exists a double or triple bond between two adjacent carbon atoms in the carbon chain.

Alkanes, alkenes, alkynes and cycloalkanes are generally referred to as aliphatic hydrocarbons. Aliphatic hydrocarbons are hydrocarbons containing carbon and hydrogen joined together in straight chains, branched chains or non-aromatic rings.

Benzenes: Benzenes contains only carbon and hydrogen atoms; the carbon atoms are joined together to form a ring containing alternating single and double bonds. This compound is called aromatic benzene.

Alkanols

Alkanols are organic compounds containing –OH as the functional group. They can be said to be derived from alkanes by replacing the hydrogen atoms of the alkanes with –OH functional groups.

Classification of Alkanols

Alkanols can be classified base on the number of hydrogens of the alkanes replaced by the hydroxyl functional group.

a. Monohydric Alkanols
b. Polyhydric Alkanols

Monohydric Alkanols: when only one hydrogen of the alkane is replaced by one hydroxyl functional group. Monohydric alkanol is sub-divided into:

1) Primary alkanol

2) Secondary alkanol

3) Tertiary alkanol.

Primary alkanol: This is an alkanol in which the hydroxyl functional group is attached to carbon atom carrying two hydrogen atoms.

Secondary alkanol: This is an alkanol in which the hydroxyl functional group is attached to carbon atom carrying one hydrogen atom.

Tertiary alkanol: This is an alkanol in which the hydroxyl functional group is attached to carbon atom that carries no hydrogen atoms.

Polyhydric Alkanols: Alkanols containing two or more hydroxyl functional groups are called polyhydric alkanols. Polyhydric alkanol can be dihydric alkanol, trihydric alkanol e.t.c. depending on the number of the hydroxyl group present in a compound.

Other organic compounds are; halogenoalkanes, aminoalkanes, alkanones, alkanals, alkanoic acids, alkanoates(ester), alkoxyalkanes(ethers) and alkyl amide.

Analogies and students' misconceptions in Organic Chemistry

There is a need to clarify what an analogy is so that it is not confused with illustrations and examples. An analogy is an explanation that compares a fact that is unknown and unfamiliar with another known and familiar ones. An analogy is a correspondence in some respects between concepts, principles, or formulas otherwise dissimilar. More precisely, it is a mapping between similar features of those concepts, principles, and formulas (Glynn et al., 1989). The analogy requires the selection of a 'student world' analog to assist in the explanation of the content specific target (or topic).

The analog and target are subtly linked by the sharing of a concept that Glynn (1991) refers to as being 'superordinate'. The analog and target share attributes that allow for a relationship to be identified.

Analogies have been an important part of chemistry education for many years. Especially, analogies have been used to teach abstract concepts like chemical equilibrium, nature of matter and chemical bonding. Accordingly, analogies play central role in supporting the understanding of complex concepts and topics. One of the main sources of analogies is textbooks. Analogies are effective teaching tools, helping the students convey new information to the available information structure, providing meaningful learning and giving a new point of view on the subject. Analogies help to remove misconceptions and play an important role in conceptual exchange.

Nowadays, one of the problems encountered in science and chemistry education is that students could not relate between basic concepts. One effective way to deal with this problem is to provide a bridge between new concepts and knowledge what the students already know (Treagust, & Chittleborough, 2001; Thiele, & Treagust, 2010) This bridge could be provided by analogies. The use of analogies to support the learning process is not new in chemistry education. One of the first studies about the use of analogies was conducted by Lewis. According to Lewis, analogies could be used to teach abstract concepts like chemical equilibrium and nature of the matter. Because, most of freshmen could not understand properly nature of the matter with traditional presentation. In order to learn chemistry, many times students have to understand abstracts concepts (Justi &

Mozzer, 2009). To assist in the explaining of abstract chemical concepts, teachers frequently have used analogies as teaching tools. An analogy could be defined as an explicit comparison between two fields: one unknown and the other familiar to the individual (Duit, 1991; Cunha & Justi, 2009). While unknown field is identified as target or object, familiar field is named as analog, base or source. The main purpose is to compare target with analog and become easier understanding of target as analog is familiar for the individual.

Studies have shown that the use of the analogies correctly in learning process has some advantages on students' learning (Sarantopoulos & Tsaparlis, 2004). Some of them are below:

- Analogies motivate students to learn by provoking their interest.
- Analogies help students construct their own knowledge.
- Analogies provide visualization of the abstract concepts.
- Analogies help students compare similarities of students' real word and new concepts.
- Analogies enhance the teacher to take students' prior knowledge into consideration.

Disadvantages and Potential Dangers of Analogies

Analogies are "double-edged swords" (Glynn et al., 1989, p. 387), which may totally mislead. It is important to note:

- An analogy is never based on an exact fit between analog and target. There are always features of analog structure that are different from those of the target. These features may mislead.

- Analogical reasoning is only possible if the intended analogies really are drawn by the students. If students hold misconceptions in the analog domain analogical reasoning will transfer them into the target domain. It is therefore important to ensure that the intended analogies are really drawn by the students.
- Although analogical reasoning appears to be quite common both in daily life and in other contexts, spontaneous use of analogies provided by teachers or learning media seldom happens. Analogical reasoning in learning situations requires considerable guidance. Access to the analogies provided is facilitated by surface similarities and by deep structure aspects. But only the deep structure aspects have inferential power.

In the literature, analogies have been classified into different types (Thiele & Treagust, 2010; Guler & Yagbasan, 2008). These are:

- Verbal and pictorial analogies.
- Structural, functional and structural-functional analogies which represent analogical relationship between analog and target.
- Pre-organizer, buried-activator and last synthesizer analogies which represent the place of analogies in the learning process.
- Simple, widened and expanded analogies which represent wideness of analogy.

In many countries like Nigeria, textbooks are the central tools in the learning process. More than 90% of secondary school teachers use textbooks to organize and deliver instruction. Consequently, it is important to analyze the textbooks which involve analogies

used by teachers and students. Analyzing chemistry textbooks will be beneficial for textbook authors and programmers.

It is also evident that the final presentation by the classroom teacher will have a considerable influence upon the mode of operation of an analogy. Thus, there is need to study analogies and students' misconceptions in Organic Chemistry which is one of topic in chemistry that students considered to be difficult.

How Analogies in Chemistry Textbooks influence Teaching and Learning

Analogy is about relational thinking involving both social and personal constructions of knowledge. The constructivist nature of analogy has both strength and weakness of representational thinking. Analogy offers new ways of thinking and the potential to revitalize science teaching. When students study new concepts, meaningful learning proceeds when they find and visualize connections between a newly taught context and what they already know. This is especially important in inquiry learning where connections are built between familiar and non-intuitive science contexts. In analogy, a familiar entity is used to provide information, interpret or communicate ideas about a less well-known entity. If the analogies are appropriate, they promote concept learning because they encourage students to build links between past familiar knowledge, experiences and new contexts and problems.

In order that analogies are used as an effective tool in a science teaching and learning, knowledge about their pedagogical function is essential. In its most elementary form, science teachers' knowledge about analogies should include:

• The suitability of the analog to the target for the student audience and the extent of teacher-directed or student-generated mapping needed to understand the target concept;

• An understanding that an analogy does not provide learners with all facets of the target concept and that multiple analogies can better achieve this goal;

• An appreciation that not all learners are comfortable with multiple analogies because the epistemological orientation of some is to expect a single explanation for a phenomenon.

Teachers are catalysts of the expected changes in society. These demands that they should be well trained, have recourse to retraining and updating of their chemistry knowledge through in-service training, workshops, seminars and conferences. Moreover, they should be well informed on the use of analogies in teaching and learning.

Textbooks play important role in the teaching and learning of chemistry. Science textbooks are mostly used in Nigeria secondary schools. It is a frequently used instructional material for students (Akinde, 2008). This is because of their availability and the ministry of education encouraged teachers at all level to be adequate guided in their recommendation and use. Also, teachers should scrutinize the contents of the textbooks before recommending them for use in schools. Additionally, these text materials therefore should be written with the necessary vocabulary appropriate for the age and level of students using them. Textbooks must be understandable to students, appropriate for self-study and information (James & Scharmann, 2007).

Textbooks writers and teachers sometimes use analogies to help familiarize students with concepts that are abstract and outside their previous experience. To be

effective, analogies must be familiar to the students, and their features/functions must be congruent with those of the target. Analogy is the explanation of an unfamiliar concept by comparing it with a familiar concept, the unfamiliar concept is the target and the familiar concept is the analogue (Dunbar, 2001).

It is quite common to use analogies in chemistry texts. Chemistry texts that are promoted through analogies improved conceptual changes. Analogies provide an advantage for teachers in transferring new knowledge from the familiar to the unfamiliar. The analogies in a textbook can lead to disadvantages if not used appropriately (Duit et al., 2001). Analogies never share all common attributes with the target concept. In some cases, an analogue concept can replace the target concept and this can cause students to misunderstand a target concept (Duit et al., 2001: Orgill & Bodner, 2004).

The analogies in textbooks are freely used by students and teachers. The analogies in textbooks are usually used randomly and can be insufficient for students (Gilbert, 2009). This can lead to misunderstandings for students most of the time (Thiele & Treagust, 2004). Textbooks are perhaps the most vital learning material available and used in most schools. Textbooks present a treasure of knowledge to students and also boost students' interest in the subjects. Chemistry textbooks help students to repeat lesson at home or study before the lesson.

Chemistry as a subject contains many scientific terms and much abstract knowledge. In order to encourage students to understand concept, prevent memorization and increase their knowledge, chemistry textbook must contain relevant illustrations and

analogies that are attractive to students and activities that stimulates critical thinking skills and scientific inquiry.

Empirical studies on Analogies used in solving students' misconceptions in Senior Secondary School Chemistry Textbooks

Musa and Ilknur (2019) conducted a study on Misconception in Chemistry Education and Practices to Eliminate Them. It was reported that Concepts can be examined in two groups; as abstract and concrete ones. While concrete concepts are improved as a result of students' experiences, it was challenging for students to perceive abstract concepts. Since chemistry includes abstract concepts largely, it was considered to be hard to comprehend as a class by students. In fact, studies confirm this thought. On this particular issue, it was clearly stated that students present themselves in learning environment, having some sort of thoughts and acknowledgments which are scientifically incorrect by a majority. The false information or acknowledgments are called misconception in the literature.

Furthermore, it was also indicated that it was too hard to eliminate such misconceptions via the traditional teaching methods. Since each student constructs his/her own knowledge, understanding and concepts in accordance with his/her ability and experience, what matters here is, if prior knowledge of student involves any misconceptions, identification and elimination of misconceptions is important. In this context, researches on identification and then elimination of misconceptions make a significant contribution to the chemistry education. In this research, misconceptions

determined and identified in literatures on subjects considered to be abstract, complex and hard to understand for students in the field of chemistry education are studied, namely solubility equilibrium, covalent bonds, ionic bonds, hydrogen bond and molecule geometry, activity concept in elements, chemical equilibrium, dissolution, electrolyse and battery; methods to remove those misconceptions were discussed; and in this study, the method of literature review, one of the qualitative research patterns, was used. To conclude, multiple misconceptions in chemistry education, specially related to abstract subjects were determined, and it was confirmed based on the literature that the methods developed in the framework of constructivist learning theory are used to remove such misconceptions.

Soeharto et.al (2019) carried out a review on students' common misconceptions in science and their diagnostic assessment tools. It was discovered that a misconception is well-known as a barrier to students in learning science. Some topics in science learning are always giving misconception to novice students, and there have been various kinds of diagnostic assessment used by researchers to identify student misconceptions in science. The study provided information about an overview of the common topics that students usually get misconception in science, and diagnostic assessment used to identify students' misconceptions in science. Furthermore, it found that interview, simple multiple-choice tests, multiple tier tests and open-ended tests are commonly used as diagnostic tests. However, every kind of tests has benefits and drawbacks over the other when it is used in assessing student conception. An expert user like teachers and researchers must be aware when using diagnostic assessment in the learning process. The findings of the study will

help researchers and teachers to decide the best instrument to be used in assessing student misconceptions and to examine the common science topics that caused misconceptions.

The Analysis of Analogy use in Chemistry Teaching was reported by Riskiani and Hari (2019). The study identified students' knowledge about analogies and explored the potential analogies in chemistry learning. Some issues related to the use of analogies in teaching and learning were discussed. In this study, data were collected from recordings and interviews from 5 students of 11th grade at senior high school in Sleman regency, Yogyakarta, Indonesia. In the interviews, student answered question about chemistry concepts and analogies generally. In addition, the interview revealed that students liked the use of analogies in their classes and believed that they had a positive effect on their understanding of new concepts. According to them, a good analogy is an object or event that is in the natural surroundings, because it will be easier to remember. Suggestions for improving classroom analogy use were presented.

Efe and Augustine (2016) conducted research on analysis of misconceptions in organic chemistry among selected senior secondary school students in Zaria Local Government Area of Kaduna State, Nigeria. The study showed that, students have various misconceptions in organic chemistry and that there was no significant difference in the level of misconception between male and female students, their performance in organic chemistry and their academic achievement. Based on the findings, it was recommended among others that the teaching of organic chemistry should start as early as SS1 so as to allow full coverage of its content and hence familiarize the students with its components.

Ibe and Umoren (2009) have examined the misconceptions by chemistry teachers of senior secondary three (SSIII) in Cross River State, Nigeria. Concepts investigated were hydrocarbons, alkanols, alkanoic acids, pollution, classification and nomenclature of carbon compounds, natural products, chemistry in industry, extraction of metals, fats and oils, amino acids and biotechnology. The study has shown that senior secondary chemistry teachers do have some misconceptions in hydrocarbon, pollution, classification and nomenclature of carbon compounds, extraction of metals, fats and oil, alkanols, alkanoic acids, biotechnology and amino acids. It was concluded that students may be negatively impacted by misconceptions during classroom interactions and may thus not have a full grasp of what specialists expect from them during evaluation of what have been studied at this level.

Topal et al (2007) conducted a study to determine the misconceptions in Aromaticity for the first and third grade students attending Department of Chemistry in Faculty of Sciences and Arts, and Faculty of Education in Dicle University and eleventh (last) grade secondary students. It was discovered that the Aromaticity concept was given in a less amount in secondary school chemistry instruction program or even insufficient and misconceived form in some chemistry books by reviewing the last grade of secondary school chemistry textbooks. The findings of this study showed that the students have had misconceptions about this subject. So, the secondary school instruction program could be reviewed and given place about aromaticity concept on a large scale.

Appraisal of the Reviewed Literature

The review of literature has enabled the researcher to provide useful information to the problem under study. From the review, learning theories such as Teaching with Analogies model, cognitive learning theory and constructivism learning theory were reviewed.

Sendur et al (2010) conducted research on an analysis of analogies used in ninth grade and tenth grade chemistry textbooks in Turkey. As a result of this study, a total of twenty-two analogies were identified from two textbooks. While seventeen analogies of these are in the tenth grades chemistry textbook, the other five in the ninth grades chemistry textbook. The Study provide an insight to the present study but this current study will focus on five different chemistry textbooks and the study would be carried out in Nigeria.

Musa and Ilknur (2019) analyzed Misconception in Chemistry Education and Practices to Eliminate Them. Samples of this study consist of the literatures related to the misconceptions in chemistry education, accessible in various databases between 2000 and 2016, and also the methods to eliminate those misconceptions. The purpose of this study requires a thorough literature analysis. As a conclusion of this study, many misconceptions, particularly on dissolution, melting, solubility equilibrium, chemical equilibrium, ionic bond, covalent bond, double and triple bonds, hydrogen bond and its molecular geometry, activity, electrolyze and battery, have been identified in related literatures for each age group of students in chemistry education. In this present study, samples will be taken from

the content of organic chemistry of the chemistry textbooks and literatures related to organic chemistry would be reviewed.

Efe and Augustine (2016) conducted a study on an analysis of misconceptions in organic chemistry among selected senior secondary school students in Zaria Local Government Area of Kaduna State, Nigeria. The study was conducted using 120 Senior Secondary III (SS3) students with an age range of 15-20 years randomly drawn from two single sex public schools and one co-educational private school, in Zaria Local Government of Kaduna State. Two research instruments were used to collect data for the study. One is a set of Organic Chemistry Misconception Test (OCMT) questions designed to obtain and identify students' achievement and misconception in organic chemistry. It contains thirty (30) multiple choice items drawn from chemistry texts and the West African Examination Council (WAEC) past question papers. Each item of the test includes one correct answer and three distracters lettered A to D. Each item requires students to select scientifically complete response. Two different categories which help to classify scientifically accepted and unacceptable explanations were determined. These categories are: Scientifically Correct (SC) and Specific Misconception (SM). The data that was collected were analysed using frequency, percentages, mean, standard deviation and t-test statistics to test the hypotheses and research questions that were formulated. In this present study, the data collected from the textbooks would be analyse using frequency, percentage and Pie Chart. The relevance and appropriateness of the analogies to the teaching and learning of chemistry would also be determine.

After reviewing the literatures related to this study, some differences were observed such as those related to geographical and content scope of the studies reviewed, research designs and instrument, different statistical tools, population and sample, the researcher used varying sampling technique to select the sample. However, this study would be carried out in Nigeria making use of some chemistry textbooks selected from the recommended list of chemistry textbooks for senior secondary schools by Ministry of Education in Kwara State.

CHAPTER THREE

RESEARCH METHODS

This chapter described the method that was adopted to carry out the research under the following sub headings: Research type, population, sample and sampling techniques, Research instruments, validation of the instrument, procedure for data collection and data analysis technique.

Research Type

This study employed the descriptive research of the survey type. The survey type of research enabled the researcher to know the types of analogies used in the selected textbooks. According to this method, the data was obtained by reading, summarizing and interpreting the textbooks based on the adopted criteria. The identified analogies were categorized based on the criteria by Thiele & Treagust (1994). The findings obtained would be presented to the reader in an organized and interpreted way. Therefore, data obtained were primarily described systematically and these descriptions were explained and interpreted.

Population, Sample and Sampling Techniques

The population for this study comprised five senior secondary school chemistry textbooks used in Ilorin, Kwara State. The sample for this study comprised three chemistry textbooks selected purposively from Kwara State Ministry of Education and Human Capital Development 2021-2024 Approved List of Books for Senior Secondary Schools 1-3 due to their availability and two other chemistry textbooks frequently used by senior

secondary schools in Ilorin, Kwara State, Nigeria. The analogies were selected purposively. Purposive sampling involves selecting samples by some arbitrary method because it is known to be representative of the total population and known to produce well matched groups. It picks out the sample in relation to some criteria, which are considered important for a particular study.

Research Instrument

Five Chemistry Textbooks were read three times by the researcher and all statements considered to be analogy were marked, photocopy and passed on to the researcher's supervisor for scrutiny. The analogies were classified based on classification scheme by Thiele and Treagust (1994) which are; the level of target concept, the analogical relationship between analogue and target, the presentation format, the level of abstraction of the analogue and target concepts, the position of the analogue to the target, the level of enrichment, pre-topic orientation and the limitations of the analogy. A pro forma of the identified analogies were developed.

Validation of Research Instruments

The marked and selected analogies in the textbooks were taken to the researcher's supervisor for scrutiny and approval. The pro forma developed were given to experts in the field of science education and physical science (two chemistry lecturers and one chemistry teacher) to determine the relevance and appropriateness. The reliability of the instrument was analyzed by three experts.

Procedure for Data Collection

The researcher personally visited the office of the Directorate of school services, Ministry of Education in Kwara State and officially requested for the recommended list of chemistry textbooks by giving them request letter and an approved letter of introduction received from the Head of Department of Science Education Department, University of Ilorin. To collect data needed for the study, there chemistry textbooks selected out of the Kwara State Ministry of Education and Human Capital Development 2021-2024 Approved List of Books for Senior Secondary Schools 1-3 and two other chemistry textbooks were read three times, analogies related to organic chemistry were pointed out in accordance to the earlier stated criteria and were thoroughly checked by the researcher's supervisor before use.

All ethical issues were addressed in this research. The study did not intend to reflect negatively on textbook writers or their writing habits but to enhance quality teaching in chemistry. The researcher also ensured that all works cited are referenced and in addition, the review of related literatures were carefully and objectively done and acts of plagiarism were prevented. The information gotten were treated with utmost confidentiality and used for the research purpose only.

Data Analysis Techniques

The Research questions were answered using frequency counts, percentage, and bar charts. Bar charts were used to show the degree of relevance and appropriateness of the identified analogies.

Table 3

List of selected Chemistry Textbooks Used in Nigerian Senior Secondary Schools

S/N	Code	Name of Textbooks	Authors	Publishers	Place and year of publication
1	BOOK A	Essential Chemistry for Senior Secondary Schools	Odesina I.A.	Tonad Publishers Limited	Ibafo (Nigeria)/ 2020
2	BOOK B	Understanding Chemistry for Schools and Colleges	Godwin O. Ojokuku	PRESS-ON CHEMBOOKS	Zaria (Nigeria)/ 2019
3	BOOK C	New School Chemistry for Senior Secondary Schools	Osei Yaw Ababio	Africana First Publishers PLC	Onitsha (Nigeria)/ 2016
4	BOOK D	Lamlad's SSCE & UTME CHEMISTRY	F.O. Ayinde & F.O. Asubiojo	Lamlad Publications LTD	Ekiti (Nigera) / 2011
5	BOOK E	Macmillan Chemistry for Senior Secondary Schools	A.A. Demehin, P.C. Onianwa, P.A. Oshinyemi, Seyi Thomas	Macmillan Nigeria Publishers Limited	Lagos (Nigeria)/ 2011

Table 4

Thiele and Treagust (1994)

Framework for categorization of Analogies

Criteria	Types of analogies	Description
Presentation	Verbal	The analogy is presented in the text in a verbal format only.
	Pictorial-verbal	The analogy is presented in a verbal format along with a picture of the analogue.
Nature of shared attributes	Structural	Analogue and target concepts in an analogy share similar attributes such as shape, size, color. e.t.c.
	Functional	Analogue and target concepts in an analogy share similar attributes such as function, behavior. e.t.c.
	Structural-functional	Analogue and target concepts in an analogy share both structural and functional attributes.
Position of analogue to the target	Embedded activator	The analogue concept is presented in the text with the target concept.
	Post synthesizer	The analogue concept is presented in the text after the target concepts.
	Advance organizer	The analogue concept is presented in the text before the target concept.

Criteria	Types of analogies	Description
Abstraction	Concrete-concrete	Both the analogue and target concepts are of a concrete nature.
	Abstract-abstract	Both the analogue and target concepts are of an abstract nature.
	Concrete-abstract	The analogue concept is of a concrete nature but the target concept is abstract.
Level of enrichment	Simple	Only one similarity is underlined between the analogue and target concepts. An analogy is formed from a simple sentence with no details.
	Enriched	Two similarity dimensions between the analogue and target concepts are underlined. An analogical statement is formed from sentences that are basic for analogies.
	Extended	Three or more similarity dimensions between the analogue and target concepts are emphasized.
Use of the term 'analogy'	Used	Included terms like 'analogy' and 'analogous'
	Not used	Does not include terms like 'analogy' and 'analogical'
Limitation	Described	Including statements analyzing the unshared attributes
	Not described	Does not include any statement of the unshared attributes

Source: Olayemi (2021)

CHAPTER FOUR

DATA ANALYSIS AND RESULTS

This chapter presented the results of the data analyzed using descriptive statistics. Specifically, the research questions were answered using frequency count, percentage, and bar chart. Bar charts were used to presented the degree of relevance and appropriateness of the identified analogies as rated by experts in the field of science education and physical science (two chemistry lecturers and one chemistry teacher). Analysis of data obtained were carried out in line with the research questions as highlighted in chapter one. Also, the chapter presented the categorization and numbers of the identified analogies in the selected chemistry textbooks, description of the identified analogies in the selected chemistry textbooks and summary of major findings.

Table 3 illustrates the textbooks information used in this study. The table shows the code of the textbook, name of the textbooks, authors, publishers, place of publication and year. All the chemistry textbooks were read over and over again by the researcher and all statements considered to be analogy were marked, photocopy and passed on to the researcher's supervisor for scrutiny in which a proforma of the identified analogies were developed.

Research Question 1: What are the types of analogies used in the selected Chemistry Textbooks to explain Organic Chemistry?

From the analysis of the selected Chemistry textbooks, a total of 117 analogies related to organic chemistry concepts were identified. It was however seen that Lamlad's SSCE & UTME Chemistry had the fewest number of analogies (17), and highest number of analogies (38) were found in New School Chemistry for Senior Secondary Schools.

In terms of presentation, 58.97% were verbal analogies while 41.03% were identified as pictorial-verbal analogy. In terms of Nature of shared attributes of analogies in the sampled textbooks, it was discovered that most of the analogies were functional analogies (39.32%) whereby the analogue and the target only shared functional attributes. Structural analogies were 38.46% and structural-functional analogies were 22.22%.

However, based on the position of analogue to the target, 97.44% of the analogies were post synthesizer i.e., presented in the text after the target concepts, 2.56% Advance organizer were identified. In terms of abstraction, 15.39% were concrete-concrete, 5.98% were abstract-abstract and 78.63% were concrete-abstract. Also, based on the level of enrichment, 43.59% analogies were simple analogies, 38.46% were enriched analogies and 17.95% were extended analogies. Furthermore, all the sampled textbooks did not use the term analogy, analogous in their textbooks and limitation of 0.85% analogy was described while 99.15% were not described.

Table 5

Categorization and numbers of analogies in the selected Nigerian Chemistry Textbooks

Category	Analogies	Book A	Book B	Book C	Book D	Book E	Total	%
Numbers		19	20	38	17	23	117	100
Presentation	Verbal	14	16	20	10	9	69	58.97
	Pictorial-verbal	5	4	18	7	14	48	41.03
Nature of shared attributes	Structural	7	3	10	8	17	45	38.46
	Functional	8	13	17	6	2	46	39.32
	Structural-functional	4	4	11	3	4	26	22.22
Position of analogue to the target	Embedded activator	0	0	0	0	0	0	0
	Post synthesizer	17	20	37	17	23	114	97.44
	Advance organizer	2	0	1	0	0	3	2.56
Abstraction	Concrete-concrete	2	4	10	1	1	18	15.39
	Abstract-abstract	4	1	2	0	0	7	5.98
	Concrete-abstract	13	15	26	16	22	92	78.63
Level of enrichment	Simple	12	11	12	9	7	51	43.59
	Enriched	5	6	22	4	8	45	38.46
	Extended	2	3	4	4	8	21	17.95
Use of the term ‘analogy’	Used	0	0	0	0	0	0	0
	Not used	19	20	38	17	23	117	100
Limitation	Described	0	0	0	0	1	1	0.85
	Not described	19	20	38	17	22	116	99.15

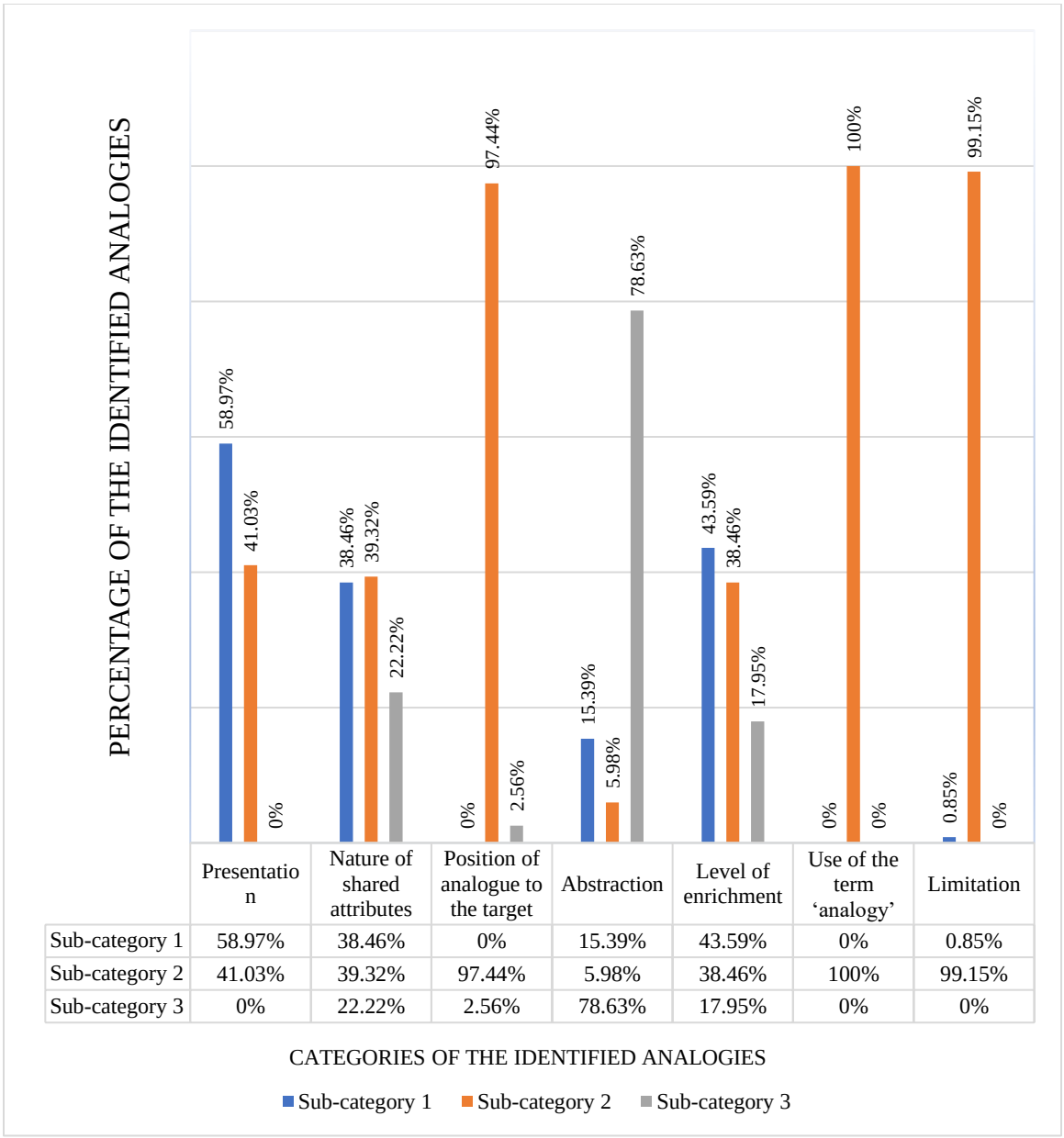

Figure 1: Categorization and Percentage of analogies in the selected Nigerian Chemistry Textbooks

Research Question 2: Are the analogies used in the selected Chemistry textbooks relevant in teaching and learning of Organic Chemistry?

Table 6 shows the degree of relevancy as rated by the experts in the field of science education and physical science (two chemistry lecturers and one chemistry teacher), while Figure 2 shows the obtained result using bar chart. The degree of relevancy as rated by the experts were above average. Hence, the identified analogies in the selected chemistry textbooks were relevant in teaching and learning of organic chemistry.

Table 6

Degree of Relevancy of the Identified Analogies

Raters	Degree of Relevancy (%)
Lecturer 1	85%
Lecturer 2	92%
Chemistry Teacher	80%

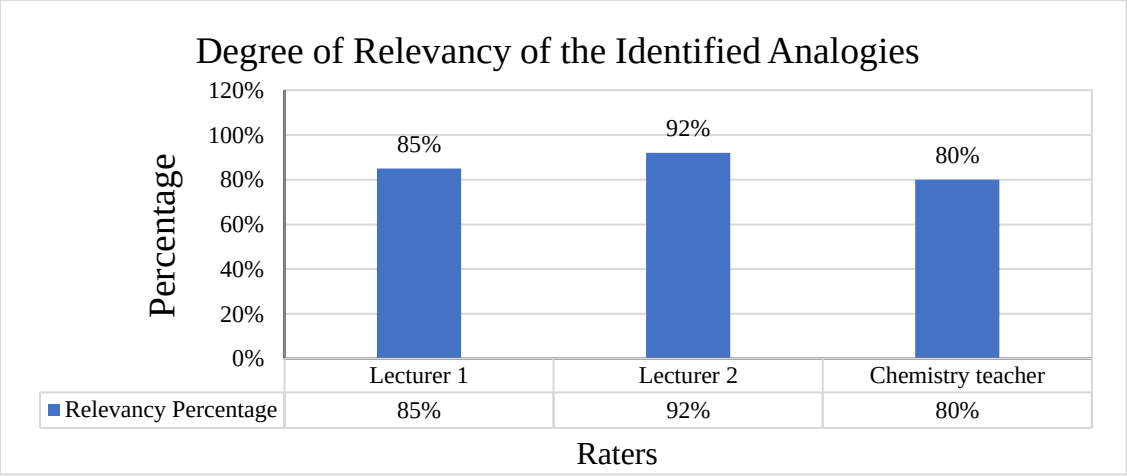

Figure 2: Bar Chart Showing the Degree of Relevancy of the Identified Analogies

Research Question 3: Are the analogies used in the selected Chemistry textbooks appropriate in teaching and learning of Organic Chemistry?

Table 7 shows the degree of appropriateness as rated by the experts in the field of science education and physical science (two chemistry lecturers and one chemistry teacher), while Figure 3 shows the obtained result using bar chart. The degree of appropriateness as rated by the experts were above average. Hence, the identified analogies in the selected chemistry textbooks were appropriate in teaching and learning of organic chemistry.

Table 7

Degree of Appropriateness of the Identified Analogies

Raters	Degree of Appropriateness (%)
Lecturer 1	93%
Lecturer 2	88%
Chemistry Teacher	90%

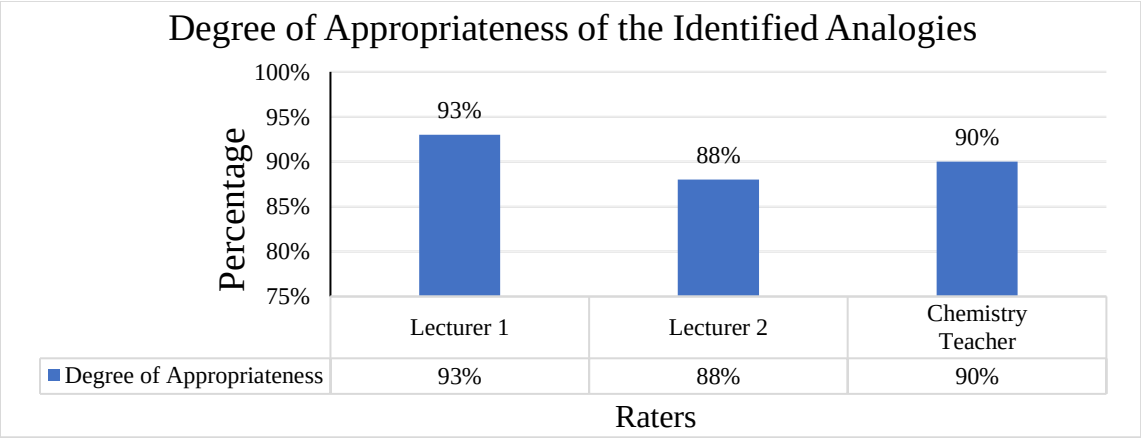

Figure 3: Bar Chart Showing the Degree of appropriateness of the Identified Analogies

Research Question 4: How are the textbooks ranked according to the numbers of analogies used?

From table 8, it is evident that New School Chemistry for Senior Secondary Schools (38) used the highest numbers of analogies related to organic chemistry, followed by Macmillan Chemistry for Senior Secondary Schools (23), followed by Understanding Chemistry for Schools and Colleges (20). Then, Essential Chemistry for Senior Secondary Schools (19) and Lamlad's SSCE & UTME Chemistry (17) used the least numbers of analogies.

Table 8

Ranked of Sampled Textbooks according to the Numbers of Analogies used

S/N	Code	Textbooks	Rank
1	Book C	New School Chemistry for Senior Secondary Schools	1st
2	Book E	Macmillan Chemistry for Senior Secondary Schools	2nd
3	Book B	Understanding Chemistry for Schools and Colleges	3rd
4	Book A	Essential Chemistry for Senior Secondary Schools	4th
5	Book D	Lamlad's SSCE & UTME Chemistry	5th

Description and determination of relevance and appropriateness of identified analogies in Essential Chemistry for Senior Secondary Schools Textbook

S/N	Analogy Identified	Page No	Criteria for Classification	Description of Analogy	Appropriateness	Relevancy
1.	Catenation is the ability of carbon atoms to combine with one another to form straight, branched or ring compounds.	425	Presentation: Verbal Nature of shared attributes: Structural Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Extended Use of the term Analogy: Not used Limitation: Not described.	The analogy is verbal because it is presented in the text in a verbal format only. Ability of carbon atoms to combine with one another to form straight, branched or ring compounds is the analogue while catenation is the target concept. It is structural because the analogue presents the structure of the target concept. concrete-abstract means the analogue concept is of a concrete nature but the target concept is abstract. The level of enrichment is extended because three similarities dimension between the analogue and target concept was emphasized.	Appropriate	Relevant

S/N	Analogy Identified	Page No	Criteria for Classification	Description of Analogy	Appropriateness	Relevancy
2.	Structure of butane, 2-methylpropane, cyclobutane, but-2-ene and prop-1-yne (propyne).	426	Presentation: Pictorial-verbal Nature of shared attributes: Structural Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Extended Use of the term Analogy: Not used Limitation: Not described.	Structure of butane, 2-methylpropane, cyclobutane, but-2-ene and prop-1-yne (propyne) are the analogues while butane, 2-methylpropane, cyclobutane, but-2-ene and prop-1-yne (propyne) are the target concepts.	Appropriate	Relevant
3.	Straight and branched chain aliphatic compounds are called acyclic compound.	437	Presentation: Verbal Nature of shared attributes: Structural Position of analogue to the target: Advance organizer Abstraction: Concrete-abstract Level of enrichment: Enriched Use of the term Analogy: Not used Limitation: Not described.	The analogy is verbal because it is presented in the text in a verbal format only. Straight and branched chain aliphatic compounds are the analogues while acyclic compound is the target concept. It is structural because the analogues present the structure of the target concept.	Appropriate	Relevant
4.	Carbon atoms of open aliphatic chain joined together to form a closed system or	437	Presentation: Verbal Nature of shared attributes: Structural Position of analogue to the target: Advance organizer	The analogy is verbal because it is presented in the text in a verbal format only. Carbon atoms of open aliphatic	Appropriate	Relevant

S/N	Analogy Identified	Page No	Criteria for Classification	Description of Analogy	Appropriateness	Relevancy
	ring are known as cyclic compound.		Abstraction: Concrete-abstract Level of enrichment: Simple Use of the term Analogy: Not used Limitation: Not described.	chain joined together to form a closed system or ring is the analogue while cyclic compound is the target concept. It is structural because the analogue presents the structure of the target concept.		
5.	Coal is a solid fuel.	437	Presentation: Verbal Nature of shared attributes: Functional Position of analogue to the target: Post synthesizer Abstraction: Concrete-concrete Level of enrichment: Simple Use of the term Analogy: Not used Limitation: Not described.	The analogy is verbal because it is presented in the text in a verbal format only. Solid fuel is the analogue while coal is the target concept. It is functional because the analogue presents the function of the target concept.	Appropriate	Relevant
6.	Petroleum is a dark viscous liquid fuel.	437	Presentation: Verbal Nature of shared attributes: Functional Position of analogue to the target: Post synthesizer Abstraction: Concrete-concrete	The analogy is verbal because it is presented in the text in a verbal format only. Dark viscous liquid fuel is the analogue while Petroleum is the target concept.	Appropriate	Relevant

S/N	Analogy Identified	Page No	Criteria for Classification	Description of Analogy	Appropriateness	Relevancy
			Level of enrichment: Simple Use of the term Analogy: Not used Limitation: Not described.	It is functional because the analogue presents the function of the target concept.		
7.	Gas is a gaseous fuel.	437	Presentation: Verbal Nature of shared attributes: Functional Position of analogue to the target: Post synthesizer Abstraction: Abstract-abstract Level of enrichment: Simple Use of the term Analogy: Not used Limitation: Not described.	The analogy is verbal because it is presented in the text in a verbal format only. Gaseous fuel is the analogue while Gas is the target concept. It is functional because the analogue presents the function of the target concept.	Appropriate	Relevant
8.	Alkanes are tetrahedral in shape.	439	Presentation: Verbal Nature of shared attributes: Structural Position of analogue to the target: Post synthesizer Abstraction: Abstract-abstract Level of enrichment: Simple Use of the term Analogy: Not used Limitation: Not described.	The analogy is verbal because it is presented in the text in a verbal format only. Tetrahedral in shape is the analogue while Alkanes is the target concept. The analogy is Structural because the analogue and target concept share similar attributes such as shape.	Appropriate	Relevant

S/N	Analogy Identified	Page No	Criteria for Classification	Description of Analogy	Appropriateness	Relevancy
9.	Pictorial representation of laboratory preparation of methane.	440	Presentation: Pictorial-verbal Nature of shared attributes: Structural-functional Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Enriched Use of the term Analogy: Not used Limitation: Not described.	The analogy is pictorial-verbal because it is presented in a verbal format along with a picture of the analogue. Picture of Laboratory preparation of methane is the analogue while Laboratory preparation of methane is the target concept. It is Structural-functional meaning analogue and target concept share both structural and functional attribute.	Appropriate	Relevant
10.	Pictorial representation of laboratory preparation of ethene.	443	Presentation: Pictorial-verbal Nature of shared attributes: Structural-functional Position of analogue to the target: Post synthesizer Abstraction: concrete-abstract Level of enrichment: Enriched Use of the term Analogy: Not used Limitation: Not described.	The analogy is pictorial-verbal because it is presented in a verbal format along with a picture of the analogue. Picture of Laboratory preparation of ethene is the analogue while Laboratory preparation of ethene is the target concept. It is Structural-functional meaning the analogue and target concept share	Appropriate	Relevant

S/N	Analogy Identified	Page No	Criteria for Classification	Description of Analogy	Appropriateness	Relevancy
				both structural and functional attribute.		
11.	Ethene is a colourless gas with a faint sweetish smell.	443	Presentation: Verbal Nature of shared attributes: Functional Position of analogue to the target: Post synthesizer Abstraction: Abstract-abstract Level of enrichment: Simple Use of the term Analogy: Not used Limitation: Not described.	The analogy is verbal because it is presented in the text in a verbal format only. Colourless gas with a faint sweetish smell is the analogue while ethene is the target concept.	Appropriate	Relevant
12.	Ozonides are viscous liquids.	446	Presentation: Verbal Nature of shared attributes: Functional Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Simple Use of the term Analogy: Not used Limitation: Not described.	The analogy is verbal because it is presented in the text in a verbal format only. Viscous liquid is the analogue while Ozonide is the target concept.	Appropriate	Relevant
13.	Pictorial representation of Laboratory	449	Presentation: Pictorial-verbal	The analogy is pictorial-verbal because it is presented in a verbal	Appropriate	Relevant

S/N	Analogy Identified	Page No	Criteria for Classification	Description of Analogy	Appropriateness	Relevancy
	preparation of ethyne.		Nature of shared attributes: Structural-functional Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Enriched Use of the term Analogy: Not used Limitation: Not described.	format along with a picture of the analogue. Picture of Laboratory preparation of ethyne is the analogue while Laboratory preparation of ethyne is the target concept. It is Structural-functional meaning the analogue and target concept share both structural and functional attribute.		
14.	Pure ethyne is a colourless gas with a characteristic sweet smell.	449	Presentation: Verbal Nature of shared attributes: Functional Position of analogue to the target: Post synthesizer Abstraction: Abstract-abstract Level of enrichment: Simple Use of the term Analogy: Not used Limitation: Not described.	The analogy is verbal because it is presented in the text in a verbal format only. Colourless gas with a characteristic sweet smell is the analogue while pure ethyne is the target concept.	Appropriate	Relevant
15.	The structure of benzene molecule is represented as a regular hexagon with alternate single and double lines which	453	Presentation: Verbal Nature of shared attributes: Structural Position of analogue to the target: Post synthesizer	The analogy is verbal because it is presented in the text in a verbal format only. Regular hexagon with alternate single and	Appropriate	Relevant

S/N	Analogy Identified	Page No	Criteria for Classification	Description of Analogy	Appropriateness	Relevancy
	indicate single and double bonds.		Abstraction: Concrete-abstract Level of enrichment: Simple Use of the term Analogy: Not used Limitation: Not described.	double lines which indicate single and double bonds is the analogue while structure of benzene molecule is the target concept.		
16.	Modern structure of benzene is a plain hexagon with an inscribed circle.	453	Presentation: Verbal Nature of shared attributes: Structural Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Simple Use of the term Analogy: Not used Limitation: Not described.	The analogy is verbal because it is presented in the text in a verbal format only. A plain hexagon with an inscribed circle is the analogue while modern structure of benzene is the target concept.	Appropriate	Relevant
17.	Benzene is a colourless volatile liquid with a sweet smell.	453	Presentation: Verbal Nature of shared attributes: Functional Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Simple Use of the term Analogy: Not used Limitation: Not described.	The analogy is verbal because it is presented in the text in a verbal format only. A colourless volatile liquid with a sweet smell is the analogue while benzene is the target concept.	Appropriate	Relevant

S/N	Analogy Identified	Page No	Criteria for Classification	Description of Analogy	Appropriateness	Relevancy
18.	Pictorial representation of Laboratory preparation of ethanol.	457	Presentation: Pictorial-verbal Nature of shared attributes: Structural-functional Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Enriched Use of the term Analogy: Not used Limitation: Not described.	The analogy is pictorial-verbal because it is presented in a verbal format along with a picture of the analogue. Picture of Laboratory preparation of ethanol is the analogue while Laboratory preparation of ethanol is the target concept.	Appropriate	Relevant
19.	Ethanol is a colourless volatile liquid with a characteristic taste and smell.	459	Presentation: Verbal Nature of shared attributes: Functional Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Simple Use of the term Analogy: Not used Limitation: Not described.	The analogy is verbal because it is presented in the text in a verbal format only. Colourless volatile liquid with a characteristic taste and smell is the analogue while ethanol is the target concept.	Appropriate	Relevant

Description and determination of relevance and appropriateness of identified analogies in Understanding Chemistry for Schools and Colleges Textbook

S/N	Analogy Identified	Page No	Criteria for Classification	Description of Analogy	Appropriateness	Relevancy
1.	Aliphatic hydrocarbons are those in which the carbon atoms form either straight or branched chains or rings.	367	Presentation: Verbal Nature of shared attributes: Structural Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Simple Use of the term Analogy: Not used Limitation: Not described.	The analogy is verbal because it is presented in the text in a verbal format only. Compound in which the carbon atoms form either straight or branched chains or rings is the analogue while Aliphatic hydrocarbon is the target concept.	Appropriate	Relevant
2.	Pictorial representation of laboratory preparation of methane.	372	Presentation: Pictorial-verbal Nature of shared attributes: Structural-functional Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Enriched Use of the term Analogy: Not used Limitation: Not described.	The analogy is pictorial-verbal because it is presented in a verbal format along with a picture of the analogue. Picture of laboratory preparation of methane is the analogue while laboratory preparation of methane is the target concept.	Appropriate	Relevant

S/N	Analogy Identified	Page No	Criteria for Classification	Description of Analogy	Appropriateness	Relevancy
3.	Pictorial representation of laboratory preparation of ethene from ethanol.	377	Presentation: Pictorial-verbal Nature of shared attributes: Structural-functional Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Enriched Use of the term Analogy: Not used Limitation: Not described.	The analogy is pictorial-verbal because it is presented in a verbal format along with a picture of the analogue. Picture of laboratory preparation of ethene from ethanol is the analogue while laboratory preparation of ethene is the target concept.	Appropriate	Relevant
4.	Pictorial representation of laboratory preparation of ethyne.	381	Presentation: Pictorial-verbal Nature of shared attributes: Structural-functional Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Enriched Use of the term Analogy: Not used Limitation: Not described.	The analogy is pictorial-verbal because it is presented in a verbal format along with a picture of the analogue. Picture of laboratory preparation of ethyne is the analogue while laboratory preparation of ethyne is the target concept.	Appropriate	Relevant
5.	Cyclic aliphatic hydrocarbons are compounds in which carbon atoms are	383	Presentation: Verbal Nature of shared attributes: Structural	The analogy is verbal because it is presented in the text in a verbal format only. Compounds in which	Appropriate	Relevant

S/N	Analogy Identified	Page No	Criteria for Classification	Description of Analogy	Appropriateness	Relevancy
	bonded together in a cyclic fashion.		Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Simple Use of the term Analogy: Not used Limitation: Not described.	carbon atoms are bonded together in a cyclic fashion is the analogue while Cyclic aliphatic hydrocarbon is the target concept.		
6.	Benzene is described as six membered monocyclic compound with alternating single and double bonds.	384	Presentation: Verbal Nature of shared attributes: Structural Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Simple Use of the term Analogy: Not used Limitation: Not described.	The analogy is verbal because it is presented in the text in a verbal format only. Six membered monocyclic compound with alternating single and double bonds is the analogue while Benzene is the target concept.	Appropriate	Relevant
7.	Benzene is a colourless liquid having unpleasant vapour, toxic and highly flammable.	385	Presentation: Verbal Nature of shared attributes: Functional Position of analogue to the target: Post synthesizer Abstraction: Abstract-abstract Level of enrichment: Extended	The analogy is verbal because it is presented in the text in a verbal format only. A colourless liquid having unpleasant vapour, toxic and highly flammable is the analogue while benzene is the target concept.	Appropriate	Relevant

S/N	Analogy Identified	Page No	Criteria for Classification	Description of Analogy	Appropriateness	Relevancy
			Use of the term Analogy: Not used Limitation: Not described.			
8.	Plastics are light, soft or hard, flexible, tough, and with great tensile strengths solid.	388	Presentation: Verbal Nature of shared attributes: Functional Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Extended Use of the term Analogy: Not used Limitation: Not described.	The analogy is verbal because it is presented in the text in a verbal format only. Light, soft or hard, flexible, tough, and with great tensile strengths solid is the analogue while Plastics is the target concept.	Appropriate	Relevant
9.	Latex is a naturally occurring milky and sticky fluid from rubber trees.	388	Presentation: Verbal Nature of shared attributes: Functional Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Simple Use of the term Analogy: Not used Limitation: Not described.	The analogy is verbal because it is presented in the text in a verbal format only. Naturally occurring milky and sticky fluid from rubber trees is the analogue while Latex is the target concept.	Appropriate	Relevant

S/N	Analogy Identified	Page No	Criteria for Classification	Description of Analogy	Appropriateness	Relevancy
10.	Ebonite is a tough and hard inelastic rubber.	389	Presentation: Verbal Nature of shared attributes: Functional Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Simple Use of the term Analogy: Not used Limitation: Not described.	The analogy is verbal because it is presented in the text in a verbal format only. A tough and hard inelastic rubber is the analogue while Ebonite is the target concept.	Appropriate	Relevant
11.	Petroleum or crude oil occurs naturally as a dark brown viscous liquid with unpleasant smell.	390	Presentation: Verbal Nature of shared attributes: Functional Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Simple Use of the term Analogy: Not used Limitation: Not described.	The analogy is verbal because it is presented in the text in a verbal format only. A dark brown viscous liquid with unpleasant smell is the analogue while Petroleum or crude oil is the target concept.	Appropriate	Relevant
12.	Pictorial representation of fractionating tower.	390	Presentation: Pictorial-verbal Nature of shared attributes: Structural-functional	The analogy is pictorial-verbal because it is presented in a verbal format along with a picture of the analogue. Picture of fractionating tower	Appropriate	Relevant

S/N	Analogy Identified	Page No	Criteria for Classification	Description of Analogy	Appropriateness	Relevancy
			Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Enriched Use of the term Analogy: Not used Limitation: Not described.	is the analogue while fractionating tower is the target concept.		
13.	Paraffin oil is described as liquid kerosene.	391	Presentation: Verbal Nature of shared attributes: Functional Position of analogue to the target: Post synthesizer Abstraction: Concrete-concrete Level of enrichment: Simple Use of the term Analogy: Not used Limitation: Not described.	The analogy is verbal because it is presented in the text in a verbal format only. Liquid kerosene is the analogue while paraffin oil is the target concept.	Appropriate	Relevant
14.	Diesel oil is described as fuel oil.	391	Presentation: Verbal Nature of shared attributes: Functional Position of analogue to the target: Post synthesizer Abstraction: Concrete-concrete Level of enrichment: Simple	The analogy is verbal because it is presented in the text in a verbal format only. Fuel oil is the analogue while Diesel oil is the target concept.	Appropriate	Relevant

S/N	Analogy Identified	Page No	Criteria for Classification	Description of Analogy	Appropriateness	Relevancy
			Use of the term Analogy: Not used Limitation: Not described.			
15.	Bitumen or asphalt is a black sticky residue left after the refining of crude oil	391	Presentation: Verbal Nature of shared attributes: Functional Position of analogue to the target: Post synthesizer Abstraction: Concrete-concrete Level of enrichment: Simple Use of the term Analogy: Not used Limitation: Not described.	The analogy is verbal because it is presented in the text in a verbal format only. Black sticky residue left after the refining of crude oil is the analogue while Bitumen or asphalt is the target concept.	Appropriate	Relevant
16.	Palm wine is a white liquid that occurs naturally in oil-palm trees.	397	Presentation: Verbal Nature of shared attributes: Functional Position of analogue to the target: Post synthesizer Abstraction: Concrete-concrete Level of enrichment: Simple Use of the term Analogy: Not used Limitation: Not described.	The analogy is verbal because it is presented in the text in a verbal format only. A white liquid that occurs naturally in oil-palm trees is the analogue while Palm wine is the target concept.	Appropriate	Relevant
17.	Ethanol is a colourless liquid	397	Presentation: Verbal	The analogy is verbal because it is presented	Appropriate	Relevant

S/N	Analogy Identified	Page No	Criteria for Classification	Description of Analogy	Appropriateness	Relevancy
	with a burning taste and a pleasant odour.		Nature of shared attributes: Functional Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Extended Use of the term Analogy: Not used Limitation: Not described.	in the text in a verbal format only. Colourless liquid with a burning taste and a pleasant odour is the analogue while Ethanol is the target concept.		
18.	Methanol is a colourless hygroscopic liquid with a sweet smell.	400	Presentation: Verbal Nature of shared attributes: Functional Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Enriched Use of the term Analogy: Not used Limitation: Not described.	The analogy is verbal because it is presented in the text in a verbal format only. Colourless hygroscopic liquid with a sweet smell is the analogue while methanol is the target concept.	Appropriate	Relevant
19.	Ethanediol is a colourless viscous liquid with a sweet taste.	401	Presentation: Verbal Nature of shared attributes: Functional Position of analogue to the target: Post synthesizer	The analogy is verbal because it is presented in the text in a verbal format only. A colourless viscous liquid with a sweet taste is the analogue	Appropriate	Relevant

S/N	Analogy Identified	Page No	Criteria for Classification	Description of Analogy	Appropriateness	Relevancy
			Abstraction: Concrete-abstract Level of enrichment: Enriched Use of the term Analogy: Not used Limitation: Not described.	while Ethanediol is the target concept.		
20.	Phenol is a white crystalline solid.	401	Presentation: Verbal Nature of shared attributes: Functional Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Simple Use of the term Analogy: Not used Limitation: Not described.	The analogy is verbal because it is presented in the text in a verbal format only. A white crystalline solid that turns pink on exposure to air is the analogue while phenol is the target concept.	Appropriate	Relevant

Description and determination of relevance and appropriateness of identified analogies in New School Chemistry for Senior Secondary Schools Textbook

S/N	Analogy Identified	Page No	Criteria for Classification	Description of Analogy	Appropriateness	Relevancy
1.	Petroleum occurs as a dark, sticky, viscous liquid.	506	Presentation: Verbal Nature of shared attributes: Functional Position of analogue to the target: Post synthesizer Abstraction: Concrete-concrete Level of enrichment: Extended Use of the term Analogy: Not used Limitation: Not described.	The analogy is verbal because it is presented in the text in a verbal format only. Dark, sticky, viscous liquid is the analogue while Petroleum is the target concept.	Appropriate	Relevant
2.	Pictorial representation of formation of crude oil and natural gas.	507	Presentation: Pictorial-verbal Nature of shared attributes: structural-functional Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Enriched Use of the term Analogy: Not used Limitation: Not described.	The analogy is pictorial-verbal because it is presented in the text in a verbal format along with a picture of the analogue. Picture of formation of crude oil and natural gas is the analogue while formation of crude oil and natural gas is the target concept.	Appropriate	Relevant

S/N	Analogy Identified	Page No	Criteria for Classification	Description of Analogy	Appropriateness	Relevancy
3.	Pictorial representation of crude oil producing regions of the world.	507	Presentation: Pictorial-verbal Nature of shared attributes: Structural Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Enriched Use of the term Analogy: Not used Limitation: Not described.	The analogy is pictorial-verbal because it is presented in the text in a verbal format along with a picture of the analogue. Picture of crude oil producing regions of the world is the analogue while crude oil producing regions of the world is the target concept.	Appropriate	Relevant
4.	Pictorial representation of off-shore oil rig.	508	Presentation: Pictorial-verbal Nature of shared attributes: Structural Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Enriched Use of the term Analogy: Not used Limitation: Not described.	The analogy is pictorial-verbal because it is presented in the text in a verbal format along with a picture of the analogue. Picture of off-shore oil rig is the analogue while off-shore oil rig is the target concept.	Appropriate	Relevant
5.	Pictorial representation of oil storage tanks at the waterfront.	508	Presentation: Pictorial-verbal Nature of shared attributes: Structural	The analogy is pictorial-verbal because it is presented in the text in a verbal	Appropriate	Relevant

S/N	Analogy Identified	Page No	Criteria for Classification	Description of Analogy	Appropriateness	Relevancy
			Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Enriched Use of the term Analogy: Not used Limitation: Not described.	format along with a picture of the analogue. Picture of oil storage tanks at the waterfront is the analogue while oil storage tank at the waterfront is the target concept.		
6.	Crude oil is described as black gold.	508	Presentation: Verbal Nature of shared attributes: Functional Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Simple Use of the term Analogy: Not used Limitation: Not described.	The analogy is verbal because it is presented in the text in a verbal format only. Black gold is the analogue while crude oil is the target concept.	Appropriate	Relevant
7.	Pictorial representation of the fractionation of crude oil in the laboratory.	509	Presentation: Pictorial-verbal Nature of shared attributes: Structural-functional Position of analogue to the target: Post synthesizer	The analogy is pictorial-verbal because it is presented in the text in a verbal format along with a picture of the analogue. Picture representing the fractionation of	Appropriate	Relevant

S/N	Analogy Identified	Page No	Criteria for Classification	Description of Analogy	Appropriateness	Relevancy
			Abstraction: Concrete-abstract Level of enrichment: Enriched Use of the term Analogy: Not used Limitation: Not described.	crude oil in the laboratory is the analogue while fractionation of crude oil in the laboratory is the target concept.		
8.	Pictorial representation of oil refinery. An oil refinery is a huge complex which may occupy an area as large as a town.	510	Presentation: Pictorial-verbal Nature of shared attributes: Structural-functional Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Enriched Use of the term Analogy: Not used Limitation: Not described.	The analogy is pictorial-verbal because it is presented in the text in a verbal format along with a picture of the analogue. Picture of oil refinery is the analogue while oil refinery is the target concept.	Appropriate	Relevant
9.	Lubricating oils are described as heavy oils.	511	Presentation: Verbal Nature of shared attributes: Functional Position of analogue to the target: Post synthesizer Abstraction: Concrete-concrete	The analogy is verbal because it is presented in the text in a verbal format only. Heavy oil is the analogue while Lubricating oil is the target concept.	Appropriate	Relevant

S/N	Analogy Identified	Page No	Criteria for Classification	Description of Analogy	Appropriateness	Relevancy
			Level of enrichment: Simple Use of the term Analogy: Not used Limitation: Not described.			
10.	Grease is described as semi-solid oil.	511	Presentation: Verbal Nature of shared attributes: Functional Position of analogue to the target: Post synthesizer Abstraction: Concrete-concrete Level of enrichment: Simple Use of the term Analogy: Not used Limitation: Not described.	The analogy is verbal because it is presented in the text in a verbal format only. Semi-solid oil is the analogue while grease is the target concept.	Appropriate	Relevant
11.	Vaseline and paraffin wax are described as solid oil.	511	Presentation: Verbal Nature of shared attributes: Functional Position of analogue to the target: Post synthesizer Abstraction: Concrete-concrete Level of enrichment: Simple Use of the term Analogy: Not used Limitation: Not described.	The analogy is verbal because it is presented in the text in a verbal format only. Solid oil is the analogue while Vaseline and paraffin wax is the target concept.	Appropriate	Relevant

S/N	Analogy Identified	Page No	Criteria for Classification	Description of Analogy	Appropriateness	Relevancy
12.	Pictorial representation of fractional distillation of crude oil.	511	Presentation: Pictorial-verbal Nature of shared attributes: Structural-functional Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Enriched Use of the term Analogy: Not used Limitation: Not described.	The analogy is pictorial-verbal because it is presented in the text in a verbal format along with a picture of the analogue. Picture representing fractional distillation of crude oil is the analogue while fractional distillation of crude oil is the target concept.	Appropriate	Relevant
13.	A picture of varieties of useful plastic household items used in Nigeria.	512	Presentation: Pictorial-verbal Nature of shared attributes: Structural Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Extended Use of the term Analogy: Not used Limitation: Not described.	The analogy is pictorial-verbal because it is presented in the text in a verbal format along with a picture of the analogue. Picture of varieties of useful plastic household items used in Nigeria is the analogue while useful plastic household items used in Nigeria is the target concept.	Appropriate	Relevant

S/N	Analogy Identified	Page No	Criteria for Classification	Description of Analogy	Appropriateness	Relevancy
14.	Pictorial representation of Gas cylinders.	512	Presentation: Pictorial-verbal Nature of shared attributes: Structural-functional Position of analogue to the target: Post synthesizer Abstraction: Concrete-concrete Level of enrichment: Enriched Use of the term Analogy: Not used Limitation: Not described.	The analogy is pictorial-verbal because it is presented in the text in a verbal format along with a picture of the analogue. Picture of Gas cylinders is the analogue while Natural gas is the target concept.	Appropriate	Relevant
15.	Pictorial representation of the products of oil.	513	Presentation: Pictorial-verbal Nature of shared attributes: Structural-functional Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Extended Use of the term Analogy: Not used Limitation: Not described.	The analogy is pictorial-verbal because it is presented in the text in a verbal format along with a picture of the analogue. Pictures representing the products of oil are the analogues while products of oil are the target concepts.	Appropriate	Relevant

S/N	Analogy Identified	Page No	Criteria for Classification	Description of Analogy	Appropriateness	Relevancy
16.	Crude oil is described as a dark viscous liquid found in underground deposits.	514	Presentation: Verbal Nature of shared attributes: Functional Position of analogue to the target: Post synthesizer Abstraction: Concrete-concrete Level of enrichment: Simple Use of the term Analogy: Not used Limitation: Not described.	The analogy is verbal because it is presented in the text in a verbal format only. A dark viscous liquid found in underground deposits is the analogue while Crude oil is the target concept.	Appropriate	Relevant
17.	Catenation is the ability of carbon to combine with one another to form straight chains, branched chains or ring compounds containing many carbon atoms.	517	Presentation: Verbal Nature of shared attributes: Structural Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Extended Use of the term Analogy: Not used Limitation: Not described.	The analogy is verbal because it is presented in the text in a verbal format only. The ability of carbon to combine with one another to form straight chains, branched chains or ring compounds containing many carbon atoms is the analogue while Catenation is the target concept.	Appropriate	Relevant
18.	Pictorial representation of the spatial representation of the molecular structure of pentane.	527	Presentation: Pictorial-verbal Nature of shared attributes: Structural	The analogy is pictorial-verbal because it is presented in the text in a verbal format along with a	Appropriate	Relevant

S/N	Analogy Identified	Page No	Criteria for Classification	Description of Analogy	Appropriateness	Relevancy
			Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Enriched Use of the term Analogy: Not used Limitation: Not described.	picture of the analogue. Picture of the spatial representation of the molecular structure of pentane is the analogue while molecular structure of pentane is the target concept.		
19.	Pictorial representation of the spatial representation of the molecular structure of cyclopropane.	527	Presentation: Pictorial-verbal Nature of shared attributes: Structural Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Enriched Use of the term Analogy: Not used Limitation: Not described.	The analogy is pictorial-verbal because it is presented in the text in a verbal format along with a picture of the analogue. Picture of the spatial representation of the molecular structure of cyclopropane is the analogue while molecular structure of cyclopropane is the target concept.	Appropriate	Relevant
20.	Straight and branched chain aliphatic compounds are called acyclic compound.	527	Presentation: Verbal Nature of shared attributes: Structural Position of analogue to the target: Advance organizer Abstraction: Concrete-abstract	The analogy is verbal because it is presented in the text in a verbal format only. Straight and branched chain aliphatic	Appropriate	Relevant

S/N	Analogy Identified	Page No	Criteria for Classification	Description of Analogy	Appropriateness	Relevancy
			Level of enrichment: Enriched Use of the term Analogy: Not used Limitation: Not described.	compounds are the analogues while acyclic compound is the target concept.		
21.	Aromatic compounds are described as benzene like compounds (based on structure of benzene).	528	Presentation: Verbal Nature of shared attributes: Structural Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Simple Use of the term Analogy: Not used Limitation: Not described.	The analogy is verbal because it is presented in the text in a verbal format only. Benzene like compound is the analogue while Aromatic compound is the target concept.	Appropriate	Relevant
22.	Pictorial representation of the spatial representation of the molecular structure of benzene.	528	Presentation: Pictorial-verbal Nature of shared attributes: Structural Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Enriched Use of the term Analogy: Not used Limitation: Not described.	The analogy is pictorial-verbal because it is presented in the text in a verbal format along with a picture of the analogue. Picture of the spatial representation of the molecular structure of benzene is the analogue while molecular structure	Appropriate	Relevant

S/N	Analogy Identified	Page No	Criteria for Classification	Description of Analogy	Appropriateness	Relevancy
				of benzene is the target concept.		
23.	Coal is a solid fuel.	528	Presentation: Verbal Nature of shared attributes: Functional Position of analogue to the target: Post synthesizer Abstraction: Concrete-concrete Level of enrichment: Simple Use of the term Analogy: Not used Limitation: Not described.	The analogy is verbal because it is presented in the text in a verbal format only. A solid fuel is the analogue while coal is the target concept.	Appropriate	Relevant
24.	Petroleum is a dark viscous liquid fuel.	528	Presentation: Verbal Nature of shared attributes: Functional Position of analogue to the target: Post synthesizer Abstraction: Concrete-concrete Level of enrichment: Simple Use of the term Analogy: Not used Limitation: Not described.	The analogy is verbal because it is presented in the text in a verbal format only. A dark viscous liquid fuel is the analogue while petroleum is the target concept.	Appropriate	Relevant
25.	Natural gas is a gaseous fuel.	528	Presentation: Verbal Nature of shared attributes: Functional	The analogy is verbal because it is presented in the text in a verbal	Appropriate	Relevant

S/N	Analogy Identified	Page No	Criteria for Classification	Description of Analogy	Appropriateness	Relevancy
			Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Simple Use of the term Analogy: Not used Limitation: Not described.	format only. A gaseous fuel is the analogue while natural gas is the target concept.		
26.	Pictorial representation of cracking of medicinal paraffin.	529	Presentation: Pictorial-verbal Nature of shared attributes: Structural-functional Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Enriched Use of the term Analogy: Not used Limitation: Not described.	The analogy is pictorial-verbal because it is presented in the text in a verbal format along with a picture of the analogue. Picture representing cracking of medicinal paraffin is the analogue while cracking of medicinal paraffin is the target concept.	Appropriate	Relevant
27.	Pictorial representation of laboratory preparation of Methane.	532	Presentation: Pictorial-verbal Nature of shared attributes: Structural-functional	The analogy is pictorial-verbal because it is presented in the text in a verbal format along with a picture of the analogue. Picture of	Appropriate	Relevant

S/N	Analogy Identified	Page No	Criteria for Classification	Description of Analogy	Appropriateness	Relevancy
			Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Enriched Use of the term Analogy: Not used Limitation: Not described.	laboratory preparation of Methane is the analogue while laboratory preparation of Methane is the target concept.		
28.	Ethene is a colourless gas with a faint sweetish smell.	534	Presentation: Verbal Nature of shared attributes: Functional Position of analogue to the target: Post synthesizer Abstraction: Abstract-abstract Level of enrichment: Simple Use of the term Analogy: Not used Limitation: Not described.	The analogy is verbal because it is presented in the text in a verbal format only. A colourless gas with a faint sweetish smell is the analogue while ethene is the target concept.	Appropriate	Relevant
29.	Pictorial representation of Laboratory preparation of ethene.	535	Presentation: Pictorial-verbal Nature of shared attributes: Structural-functional Position of analogue to the target: Post synthesizer	The analogy is pictorial-verbal because it is presented in the text in a verbal format along with a picture of the analogue. Picture of laboratory preparation of	Appropriate	Relevant

S/N	Analogy Identified	Page No	Criteria for Classification	Description of Analogy	Appropriateness	Relevancy
			Abstraction: Concrete-abstract Level of enrichment: Enriched Use of the term Analogy: Not used Limitation: Not described.	ethene is the analogue while laboratory preparation of ethene is the target concept.		
30.	Pictorial representation of laboratory preparation of ethyne.	537	Presentation: Pictorial-verbal Nature of shared attributes: Structural-functional Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Enriched Use of the term Analogy: Not used Limitation: Not described.	The analogy is pictorial-verbal because it is presented in the text in a verbal format along with a picture of the analogue. Picture of laboratory preparation of ethyne is the analogue while laboratory preparation of ethyne is the target concept.	Appropriate	Relevant
31.	Ethyne is a colourless gas with a characteristic sweet smell.	537	Presentation: Verbal Nature of shared attributes: Functional Position of analogue to the target: Post synthesizer Abstraction: Abstract-abstract	The analogy is verbal because it is presented in the text in a verbal format only. A colourless gas with a characteristic sweet smell is the analogue while	Appropriate	Relevant

S/N	Analogy Identified	Page No	Criteria for Classification	Description of Analogy	Appropriateness	Relevancy
			Level of enrichment: Simple Use of the term Analogy: Not used Limitation: Not described.	Ethyne is the target concept.		
32.	Benzene is a colourless liquid with a sweet smell.	541	Presentation: Verbal Nature of shared attributes: Functional Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Enriched Use of the term Analogy: Not used Limitation: Not described.	The analogy is verbal because it is presented in the text in a verbal format only. A colourless liquid with a sweet smell is the analogue while benzene is the target concept.	Appropriate	Relevant
33.	Ethanol is a colourless, volatile liquid with a characteristic taste and smell.	544	Presentation: Verbal Nature of shared attributes: Functional Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Enriched Use of the term Analogy: Not used	The analogy is verbal because it is presented in the text in a verbal format only. A colourless, volatile liquid with a characteristic taste and smell is the analogue while ethanol is the target concept.	Appropriate	Relevant

S/N	Analogy Identified	Page No	Criteria for Classification	Description of Analogy	Appropriateness	Relevancy
			Limitation: Not described.			
34.	Pictorial representation of Beer brewing plant.	546	Presentation: Pictorial-verbal Nature of shared attributes: Structural-functional Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Enriched Use of the term Analogy: Not used Limitation: Not described.	The analogy is pictorial-verbal because it is presented in the text in a verbal format along with a picture of the analogue. Picture of Beer brewing plant is the analogue while Beer brewing plant is the target concept.	Appropriate	Relevant
35.	Simple sugars are crystalline, water soluble with sweet taste substances.	562	Presentation: Verbal Nature of shared attributes: Functional Position of analogue to the target: Post synthesizer Abstraction: Concrete-concrete Level of enrichment: Enriched Use of the term Analogy: Not used Limitation: Not described.	The analogy is verbal because it is presented in the text in a verbal format only. Crystalline, water soluble with a sweet taste is the analogue while Simple sugar is the target concept.	Appropriate	Relevant

S/N	Analogy Identified	Page No	Criteria for Classification	Description of Analogy	Appropriateness	Relevancy
36.	Complex sugars are non-crystalline, insoluble and tasteless substances.	562	Presentation: Verbal Nature of shared attributes: Functional Position of analogue to the target: Post synthesizer Abstraction: Concrete-concrete Level of enrichment: Enriched Use of the term Analogy: Not used Limitation: Not described.	The analogy is verbal because it is presented in the text in a verbal format only. Non-crystalline, insoluble and tasteless substance is the analogue while Complex sugar is the target concept.	Appropriate	Relevant
37.	Sucrose is described as sugar cane.	564	Presentation: Verbal Nature of shared attributes: Functional Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Simple Use of the term Analogy: Not used Limitation: Not described.	The analogy is verbal because it is presented in the text in a verbal format only. Sugar cane is the analogue while sucrose is the target concept.	Appropriate	Relevant

S/N	Analogy Identified	Page No	Criteria for Classification	Description of Analogy	Appropriateness	Relevancy
38.	Sucrose is a colourless crystalline solid with a very sweet taste.	564	Presentation: Verbal Nature of shared attributes: Functional Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Enriched Use of the term Analogy: Not used Limitation: Not described.	The analogy is verbal because it is presented in the text in a verbal format only. A colourless crystalline solid with a very sweet taste is the analogue while sucrose is the target concept.	Appropriate	Relevant

Description and determination of relevance and appropriateness of identified analogies in Lamlad's SSCE & UTME Chemistry Textbook

S/N	Analogy Identified	Page No	Criteria for Classification	Description of Analogy	Appropriateness	Relevancy
1.	Aliphatic compounds are organic compounds in which carbon atoms are arranged in chains which may be straight or branched.	229	Presentation: Verbal Nature of shared attributes: Structural Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Simple Use of the term Analogy: Not used Limitation: Not described.	The analogy is verbal because it is presented in the text in a verbal format only. Organic compounds in which carbon atoms are arranged in chains which may be straight or branched is the analogue while Aliphatic compound is the target concept.	Appropriate	Relevant
2.	Structure of Straight chain, branched chain, chain with a double bond, chain with a triple bond.	229	Presentation: Pictorial-verbal Nature of shared attributes: Structural Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Extended Use of the term Analogy: Not used Limitation: Not described.	The analogy is pictorial-verbal because it is presented in the text in a verbal format along with a picture of the analogue. Structure of Straight chain, branched chain, chain with a double bond, chain with a triple bond are the analogues while Straight chain, branched chain, chain with a double bond, chain with a triple bond are the target concepts.	Appropriate	Relevant

S/N	Analogy Identified	Page No	Criteria for Classification	Description of Analogy	Appropriateness	Relevancy
3.	Alicyclic compounds are cyclic compounds which form their rings by attaching the two chain ends of the corresponding aliphatic compounds.	229	Presentation: Verbal Nature of shared attributes: Structural Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Simple Use of the term Analogy: Not used Limitation: Not described.	The analogy is verbal because it is presented in the text in a verbal format only. Cyclic compound which form their rings by attaching the two chain ends of the corresponding aliphatic compounds is the analogue while Alicyclic compound is the target concept.	Appropriate	Relevant
4.	Structure of 3-membered ring, 4-membered ring, 5-membered ring, 3-membered ring with a double bond.	229	Presentation: Pictorial-verbal Nature of shared attributes: Structural Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Extended Use of the term Analogy: Not used Limitation: Not described.	The analogy is pictorial-verbal because it is presented in the text in a verbal format along with a picture of the analogue. Structure of 3-membered ring, 4-membered ring, 5-membered ring, 3-membered ring with a double bond are the analogues while 3-membered ring, 4-membered ring, 5-membered ring, 3-membered ring with a double bond are the target concepts.	Appropriate	Relevant
5.	Structure of benzene,	229	Presentation: Pictorial-verbal	The analogy is pictorial-verbal	Appropriate	Relevant

S/N	Analogy Identified	Page No	Criteria for Classification	Description of Analogy	Appropriateness	Relevancy
	Naphthalene and anthracene.		Nature of shared attributes: Structural Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Extended Use of the term Analogy: Not used Limitation: Not described.	because it is presented in the text in a verbal format along with a picture of the analogue. Structure of benzene, Naphthalene and anthracene are the analogues while benzene, Naphthalene and anthracene are the target concepts.		
6.	Structure of Straight chain alkane, branched chain alkane, a cycloalkanes, ethene, ethyne, cyclopropene, benzene.	230	Presentation: Pictorial-verbal Nature of shared attributes: Structural Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Extended Use of the term Analogy: Not used Limitation: Not described.	The analogy is pictorial-verbal because it is presented in the text in a verbal format along with a picture of the analogue. Structure of Straight chain alkane, branched chain alkane, a cycloalkanes, ethene, ethyne, cyclopropene, benzene are the analogues while Straight chain alkane, branched chain alkane, a cycloalkanes, ethene, ethyne, cyclopropene, benzene are the target concepts.	Appropriate	Relevant

S/N	Analogy Identified	Page No	Criteria for Classification	Description of Analogy	Appropriateness	Relevancy
7.	Aliphatic compounds are compounds containing carbon chains which may be straight or branched.	259	Presentation: Verbal Nature of shared attributes: Structural Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Simple Use of the term Analogy: Not used Limitation: Not described.	The analogy is verbal because it is presented in the text in a verbal format only. Compounds containing carbon chains which may be straight or branched is the analogue while Aliphatic compound is the target concept.	Appropriate	Relevant
8.	Polyaromatic compounds are those compounds in which two or more benzene rings fuse together.	267	Presentation: Verbal Nature of shared attributes: Structural Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Simple Use of the term Analogy: Not used Limitation: Not described.	The analogy is verbal because it is presented in the text in a verbal format only. Compounds in which two or more benzene rings fuse together is the analogue while Polyaromatic compounds is the target concept.	Appropriate	Relevant
9.	Pictorial representation of laboratory preparation for methane.	277	Presentation: Pictorial-verbal Nature of shared attributes: Structural-functional Position of analogue to the target: Post synthesizer	The analogy is pictorial-verbal because it is presented in the text in a verbal format along with a picture of the analogue. Picture of laboratory preparation for	Appropriate	Relevant

S/N	Analogy Identified	Page No	Criteria for Classification	Description of Analogy	Appropriateness	Relevancy
			Abstraction: Concrete-abstract Level of enrichment: Enriched Use of the term Analogy: Not used Limitation: Not described.	methane is the analogue while laboratory preparation for methane is the target concept.		
10.	Polythene is described as plastic.	280	Presentation: Verbal Nature of shared attributes: Functional Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Simple Use of the term Analogy: Not used Limitation: Not described.	The analogy is verbal because it is presented in the text in a verbal format only. Plastic is the analogue while polythene is the target concept.	Appropriate	Relevant
11.	Ebonite is described as a vulcanized rubber.	280	Presentation: Verbal Nature of shared attributes: Functional Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Simple Use of the term Analogy: Not used Limitation: Not described.	The analogy is verbal because it is presented in the text in a verbal format only. Vulcanized rubber is the analogue while ebonite is the target concept.	Appropriate	Relevant

S/N	Analogy Identified	Page No	Criteria for Classification	Description of Analogy	Appropriateness	Relevancy
12.	Pictorial representation of laboratory preparation of ethene.	281	Presentation: Pictorial-verbal Nature of shared attributes: Structural-functional Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Enriched Use of the term Analogy: Not used Limitation: Not described.	The analogy is pictorial-verbal because it is presented in the text in a verbal format along with a picture of the analogue. Picture of laboratory preparation of ethene is the analogue while laboratory preparation of ethene is the target concept.	Appropriate	Relevant
13.	Pictorial representation of laboratory preparation of ethyne.	285	Presentation: Pictorial-verbal Nature of shared attributes: Structural-functional Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Enriched Use of the term Analogy: Not used Limitation: Not described.	The analogy is pictorial-verbal because it is presented in the text in a verbal format along with a picture of the analogue. Picture of laboratory preparation of ethyne is the analogue while laboratory preparation of ethyne is the target concept.	Appropriate	Relevant
14.	Petroleum (Crude-oil) is a dark brown surface underground deposit.	290	Presentation: Verbal Nature of shared attributes: Functional	The analogy is verbal because it is presented in the text in a verbal format only. A dark brown	Appropriate	Relevant

S/N	Analogy Identified	Page No	Criteria for Classification	Description of Analogy	Appropriateness	Relevancy
			Position of analogue to the target: Post synthesizer Abstraction: Concrete-concrete Level of enrichment: Simple Use of the term Analogy: Not used Limitation: Not described.	surface underground deposit is the analogue while Petroleum is the target concept.		
15.	Paraffin oil is described as Kerosene.	291	Presentation: Verbal Nature of shared attributes: Functional Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Simple Use of the term Analogy: Not used Limitation: Not described.	The analogy is verbal because it is presented in the text in a verbal format only. Kerosene is the analogue while paraffin oil is the target concept.	Appropriate	Relevant
16.	Methanol is described as a colourless liquid.	307	Presentation: Verbal Nature of shared attributes: Functional Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Simple Use of the term Analogy: Not used	The analogy is verbal because it is presented in the text in a verbal format only. A colourless liquid is the analogue while methanol is the target concept.	Appropriate	Relevant

S/N	Analogy Identified	Page No	Criteria for Classification	Description of Analogy	Appropriateness	Relevancy
			Limitation: Not described.			
17.	Ethanol is a colourless liquid with a characteristic smell and taste.	308	Presentation: Verbal Nature of shared attributes: Functional Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Enriched Use of the term Analogy: Not used Limitation: Not described.	The analogy is verbal because it is presented in the text in a verbal format only. A colourless liquid with a characteristic smell and taste is the analogue while ethanol is the target concept.	Appropriate	Relevant

Description and determination of relevance and appropriateness of identified analogies in Macmillan Chemistry for Senior Secondary Schools Textbook

S/N	Analogy Identified	Page No	Criteria for Classification	Description of Analogy	Appropriateness	Relevancy
1.	Catenation is the property exhibited by carbon to form stable carbon-carbon straight chains of various lengths as well as carbon-carbon ringed compounds.	384	Presentation: Verbal Nature of shared attribute: Structural Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Enriched Use of the term Analogy: Not used Limitation: Not described.	The analogy is verbal because it is presented in the text in a verbal format only. The property exhibited by carbon to form stable carbon-carbon straight chains of various lengths as well as carbon-carbon ringed compounds is the analogue while catenation is the target concept.	Appropriate	Relevant
2.	Acyclic or Aliphatic Organic compounds are compounds containing straight or branched chain carbon atoms with no ring structures.	385	Presentation: Verbal Nature of shared attribute: Structural Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Simple Use of the term Analogy: Not used Limitation: Described.	The analogy is verbal because it is presented in the text in a verbal format only. Compound containing straight or branched chain carbon atoms with no ring structures is the analogue while acyclic organic compound is the target concept.	Appropriate	Relevant
3.	Structures of Straight Chain and	385	Presentation: Pictorial-verbal	The analogy is pictorial-verbal because it is	Appropriate	Relevant

S/N	Analogy Identified	Page No	Criteria for Classification	Description of Analogy	Appropriateness	Relevancy
	Branched -Chain Aliphatic Organic compounds.		Nature of shared attributes: Structural Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Enriched Use of the term Analogy: Not used Limitation: Not described.	presented in the text in a verbal format along with a picture of the analogue. Structures of Straight Chain and Branched -Chain Aliphatic Organic compounds are the analogues while Straight Chain and Branched -Chain Aliphatic Organic compounds are the target concepts.		
4.	Benzenoid carbocyclic compounds are aromatic compounds containing ring chain carbon atoms based on benzene and derivatives of benzene.	386	Presentation: Verbal Nature of shared attribute: Structural Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Simple Use of the term Analogy: Not used Limitation: Not described.	The analogy is verbal because it is presented in the text in a verbal format only. Aromatic compounds containing ring chain carbon atoms based on benzene and derivatives of benzene is the analogue while Benzenoid carbocyclic compounds is the target concept.	Appropriate	Relevant
5.	Structure of Benzene, Methylbenzene (Toluene) and Hydroxybenzene (Phenol).	386	Presentation: Pictorial-verbal Nature of shared attributes: Structural Position of analogue to the target: Post synthesizer	The analogy is pictorial-verbal because it is presented in the text in a verbal format along with a picture of the analogue.	Appropriate	Relevant

S/N	Analogy Identified	Page No	Criteria for Classification	Description of Analogy	Appropriateness	Relevancy
			Abstraction: Concrete-abstract Level of enrichment: Extended Use of the term Analogy: Not used Limitation: Not described.	Structure of Benzene, Methylbenzene (Toluene) and Hydroxybenzene (Phenol) are the analogues while Benzene, Methylbenzene (Toluene) and Hydroxybenzene (Phenol) are the target concepts.		
6.	Non-Benzenoid Carbocyclic compounds are carbocyclic compounds containing ring chain carbon atoms but not based on benzene structure.	386	Presentation: Verbal Nature of shared attribute: Structural Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Simple Use of the term Analogy: Not used Limitation: Not described.	The analogy is verbal because it is presented in the text in a verbal format only. Carbocyclic compounds containing ring chain carbon atoms but not based on benzene structure is the analogue while Non-Benzenoid Carbocyclic compounds is the target concept.	Appropriate	Relevant
7.	Structure of Cyclopropane and Cyclohexane.	386	Presentation: Pictorial-verbal Nature of shared attributes: Structural Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract	The analogy is pictorial-verbal because it is presented in the text in a verbal format along with a picture of the analogue. Structure of Cyclopropane and Cyclohexane are the	Appropriate	Relevant

S/N	Analogy Identified	Page No	Criteria for Classification	Description of Analogy	Appropriateness	Relevancy
			Level of enrichment: Enriched Use of the term Analogy: Not used Limitation: Not described.	analogues while Cyclopropane and Cyclohexane are the target concepts.		
8.	Heterocyclic organic compounds are organic compounds containing ring chain of more than one kind of atom, carbon inclusive.	386	Presentation: Verbal Nature of shared attribute: Structural Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Simple Use of the term Analogy: Not used Limitation: Not described.	The analogy is verbal because it is presented in the text in a verbal format only. Organic compounds containing ring chain of more than one kind of atom, carbon inclusive is the analogue while Heterocyclic organic compound is the target concept.	Appropriate	Relevant
9.	Structure of Pyrazole, 3-methylfuran and Pyridine.	386	Presentation: Pictorial-verbal Nature of shared attributes: Structural Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Extended Use of the term Analogy: Not used Limitation: Not described.	The analogy is pictorial-verbal because it is presented in the text in a verbal format along with a picture of the analogue. Structure of Pyrazole, 3-methylfuran and Pyridine are the analogues while Pyrazole, 3-methylfuran and Pyridine are the target concepts.	Appropriate	Relevant

S/N	Analogy Identified	Page No	Criteria for Classification	Description of Analogy	Appropriateness	Relevancy
10.	Alkanes are straight or branched chain hydrocarbons in which all the adjacent carbon atoms in the molecules of the alkanes are joined by single bonds.	393	Presentation: Verbal Nature of shared attribute: Structural Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Simple Use of the term Analogy: Not used Limitation: Not described.	The analogy is verbal because it is presented in the text in a verbal format only. Straight or branched chain hydrocarbons in which all the adjacent carbon atoms in the molecules of the alkanes are joined by single bonds is the analogue while alkanes is the target concept.	Appropriate	Relevant
11.	Structure of Straight chain alkane, branched chain alkane, cyclobutane and cyclohexane.	393	Presentation: Pictorial-verbal Nature of shared attributes: Structural Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Extended Use of the term Analogy: Not used Limitation: Not described.	The analogy is pictorial-verbal because it is presented in the text in a verbal format along with a picture of the analogue. Structure of Straight chain alkane, branched chain alkane, cyclobutane and cyclohexane are the analogues while Straight chain alkane, branched chain alkane, cyclobutane and cyclohexane are the target concepts.	Appropriate	Relevant
12.	Alkenes and alkynes are straight chain or branched chain	393	Presentation: Verbal Nature of shared attribute: Structural	The analogy is verbal because it is presented in the text in a verbal format	Appropriate	Relevant

S/N	Analogy Identified	Page No	Criteria for Classification	Description of Analogy	Appropriateness	Relevancy
	hydrocarbons in which there exists a double or triple bonds between two adjacent carbon atoms in the molecules of the hydrocarbons.		Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Simple Use of the term Analogy: Not used Limitation: Not described.	only. Straight chain or branched chain hydrocarbons in which there exists a double or triple bonds between two adjacent carbon atoms in the molecules of the hydrocarbons is the analogue while Alkenes and alkynes is the target concept.		
13.	Structure of Straight chain alkenes, Branched chain alkene and Alkynes.	394	Presentation: Pictorial-verbal Nature of shared attributes: Structural Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Extended Use of the term Analogy: Not used Limitation: Not described.	The analogy is pictorial-verbal because it is presented in the text in a verbal format along with a picture of the analogue. Structure of Straight chain alkenes, branched chain alkene and Alkynes are the analogues while Straight chain alkenes, Branched chain alkene and Alkynes are the target concepts.	Appropriate	Relevant
14.	Structure of methane, ethane, propane, butane and pentane.	395	Presentation: Pictorial-verbal Nature of shared attributes: Structural Position of analogue to the target: Post synthesizer	The analogy is pictorial-verbal because it is presented in the text in a verbal format along with a picture of the analogue.	Appropriate	Relevant

S/N	Analogy Identified	Page No	Criteria for Classification	Description of Analogy	Appropriateness	Relevancy
			Abstraction: Concrete-abstract Level of enrichment: Extended Use of the term Analogy: Not used Limitation: Not described.	Structure of methane, ethane, propane, butane and pentane are the analogues while methane, ethane, propane, butane and pentane are the target concepts.		
15.	Picture of the laboratory preparation of methane.	397	Presentation: Pictorial-verbal Nature of shared attributes: Structural-functional Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Enriched Use of the term Analogy: Not used Limitation: Not described.	The analogy is pictorial-verbal because it is presented in the text in a verbal format along with a picture of the analogue. Picture of the laboratory preparation of methane is the analogue while laboratory preparation of methane is the target concept.	Appropriate	Relevant
16.	Structure of ethene, propene, butene, and pentene.	398	Presentation: Pictorial-verbal Nature of shared attributes: Structural Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Extended	The analogy is pictorial-verbal because it is presented in the text in a verbal format along with a picture of the analogue. Structure of ethene, propene, butene, and pentene are the analogues while ethene, propene,	Appropriate	Relevant

S/N	Analogy Identified	Page No	Criteria for Classification	Description of Analogy	Appropriateness	Relevancy
			Use of the term Analogy: Not used Limitation: Not described.	butene, and pentene are the target concepts.		
17.	Picture of laboratory preparation of ethene.	400	Presentation: Pictorial-verbal Nature of shared attributes: Structural-functional Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Enriched Use of the term Analogy: Not used Limitation: Not described.	The analogy is pictorial-verbal because it is presented in the text in a verbal format along with a picture of the analogue. Picture of the laboratory preparation of ethene is the analogue while laboratory preparation of ethene is the target concept.	Appropriate	Relevant
18.	Structure of ethyne, propyne, butyne, and pentyne.	404	Presentation: Pictorial-verbal Nature of shared attributes: Structural Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Extended Use of the term Analogy: Not used Limitation: Not described.	The analogy is pictorial-verbal because it is presented in the text in a verbal format along with a picture of the analogue. Structure of ethyne, propyne, butyne, and pentyne are the analogues while ethyne, propyne, butyne, and pentyne are the target concepts.	Appropriate	Relevant

S/N	Analogy Identified	Page No	Criteria for Classification	Description of Analogy	Appropriateness	Relevancy
19.	Picture representing laboratory preparation of ethyne.	405	Presentation: Pictorial-verbal Nature of shared attributes: Structural-functional Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Enriched Use of the term Analogy: Not used Limitation: Not described.	The analogy is pictorial-verbal because it is presented in the text in a verbal format along with a picture of the analogue. Picture of the laboratory preparation of ethyne is the analogue while laboratory preparation of ethyne is the target concept.	Appropriate	Relevant
20.	Structure of methanol and ethanol.	412	Presentation: Pictorial-verbal Nature of shared attributes: Structural Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Enriched Use of the term Analogy: Not used Limitation: Not described.	The analogy is pictorial-verbal because it is presented in the text in a verbal format along with a picture of the analogue. Structure of methanol and ethanol are the analogues while methanol and ethanol are the target concepts.	Appropriate	Relevant
21.	Pictorial representation of Laboratory preparation of ethanol.	413	Presentation: Pictorial-verbal Nature of shared attributes: Structural-functional	The analogy is pictorial-verbal because it is presented in the text in a verbal format along with a picture	Appropriate	Relevant

S/N	Analogy Identified	Page No	Criteria for Classification	Description of Analogy	Appropriateness	Relevancy
			Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Enriched Use of the term Analogy: Not used Limitation: Not described.	of the analogue. Pictorial representation of the laboratory preparation of ethanol is the analogue while laboratory preparation of ethanol is the target concept.		
22.	Sugars are sweet white crystalline substances.	414	Presentation: Verbal Nature of shared attribute: Functional Position of analogue to the target: Post synthesizer Abstraction: Concrete-concrete Level of enrichment: Simple Use of the term Analogy: Not used Limitation: Not described.	The analogy is verbal because it is presented in the text in a verbal format only. Sweet white crystalline substance is the analogue while Sugar is the target concept.	Appropriate	Relevant
23.	Polysaccharides are non-sugars, white non-crystalline solids and tasteless.	414	Presentation: Verbal Nature of shared attribute: Functional Position of analogue to the target: Post synthesizer Abstraction: Concrete-abstract Level of enrichment: Extended Use of the term Analogy: Not used Limitation: Not described.	The analogy is verbal because it is presented in the text in a verbal format only. Non-sugars, white non-crystalline solids and tasteless are the analogue while polysaccharide is the target concept.	Appropriate	Relevant

Summary of the major findings

The major findings of this study based on the data analyzed were summarized below.

1. All selected textbooks have varying numbers of analogies.
2. From the analysis of the selected textbooks, a total of 117 analogies related to organic chemistry concept were identified.
3. In terms of presentation, 58.97% were verbal analogies while 41.03% were identified as pictorial-verbal analogy.
4. In terms of Nature of shared attributes, it was discovered that most of the analogies were functional analogies (39.32%) whereby the analogue and the target only shared functional attributes. Structural analogies were 38.46% and structural-functional analogies were 22.22%.
5. Based on the position of analogue to the target 97.44% of the analogies were post synthesizer i.e., presented in the text after the target concepts, 2.56% Advance organizer were identified. In terms of abstraction 15.39% were concrete-concrete, 5.98% were abstract-abstract and 78.63% were Concrete-abstract.
6. Based on the level of enrichment, 43.59% analogies were simple analogies, 38.46% were enriched analogies and 17.95% were extended analogies.
7. New School Chemistry for Senior Secondary Schools (38) used the highest number of analogies related to organic chemistry, followed by Macmillan Chemistry for Senior Secondary Schools (23), Understanding Chemistry for Schools and Colleges

(20), Essential Chemistry for Senior Secondary Schools (19) and Lamlad's SSCE & UTME Chemistry (17) used the least number of analogies.

8. All the sampled textbooks did not use the term analogy, analogous in their textbooks which may imply that the Authors did not use the analogies consciously.
9. Limitation of 0.85% analogy was described while 99.15% were not described. This may be an indication that the authors may not know that analogy can bring about better understanding as well as misconception.
10. The analogies identified are substantially relevant to teaching and learning of organic chemistry concepts since they could help bring about deeper understanding by bridging the gap between known and unknown concepts.
11. The analogies identified were appropriately used.

CHAPTER FIVE
DISCUSSION, CONCLUSION AND RECOMMENDATIONS

This chapter presented the discussion of the results in the preceding chapter. Conclusions were drawn based on the results and recommendations were made. The discussion was based on the considered variables such as analogy, organic chemistry, and also suggestions were raised to encourage further studies.

Discussion

The findings of this study revealed that all the selected Chemistry textbooks contained varying numbers of analogies. From table 5, it is evident that New School Chemistry for Senior Secondary Schools (38) used the highest number of analogies related to organic chemistry, followed by Macmillan Chemistry for Senior Secondary Schools (23), Understanding Chemistry for Schools and Colleges (20), Essential Chemistry for Senior Secondary Schools (19) and Lamlad's SSCE & UTME Chemistry (17) used the least number of analogies. This showed that textbook writers have the knowledge of analogy in bringing about meaningful learning. This is in line with Onasanya (2013) who found out that the textbooks used in Nigerian secondary school has varying numbers but similar types of analogies.

The finding showed that in terms of presentation, 58.97% were verbal analogies while 41.03% were identified as pictorial-verbal analogy. This might be due to the fact that authors underestimate the power of pictorial representation of objects or concepts. This is in line with Sendur et al (2011) who stated that analogies used in the 9^{th} and 10^{th} grades

chemistry textbooks were verbal analogies and inadequate. It was suggested that analogies should be supported by pictures to visualize the abstract concepts. This however is in contrast with Ahmed et al (2015) who found out that most of the analogies identified in biology textbooks were pictorial-verbal analogies.

The finding showed that in terms of Nature of shared attributes, 39.32% of the analogies identified were functional analogies whereby the target and analogue only shared functional attributes. Structural analogies were 38.46% and structural-functional analogies were 22.22%. This implies that the author functional knowledge about analogies is deep and this will make concept concrete-abstract to the reader which will help in achieving the usefulness of analogy in the context. This is in line with the findings of Jeongho et al (2004) who stated that most of the analogies identified were mainly functional Analogies in their analysis of chemistry textbooks. This however is in contrast with the findings of Ahmed et al (2015) who stated that most of the analogies identified were mainly structural in their critical analysis of analogies related to evolution in selected biology textbooks.

The finding showed that based on the position of the analogue to the target, 97.44% of the analogies were post synthesizer i.e., presented in the text after the target concepts, 2.56% Advance organizer were identified. This implies that the analogies were presented in text after the target. This is in line with Sendur et al (2011) who concluded that last synthesizer analogies should be used in the learning process. Also, the authors might not be using the analogies consciously for them to have been able to draw a clear line between the target and analogue and in some cases, analogue concept can replace the target concept

and this can cause students to misunderstand a target concept. This is in line with Chu & Hong (2010) who stated that some analogies used for explaining concepts were not very appropriate and often mislead the students' understanding.

The finding showed that in terms of abstraction 15.39% were concrete-concrete, 5.98% were abstract-abstract and 78.63% were Concrete-abstract. This shows that the authors of the textbooks are concerned with the cognitive level of the learners and were able to put the analogies into good use by bridging the gap between known and unknown concepts by using concrete analogies which will bring about better understanding. This is in line with Yener (2012) who observed that majority of the analogy based on the level of abstraction were concrete-abstract. Since the major goal of analogy is to make abstract objects concrete for the students to visualize. This however is in contrast with the findings of Ahmed et al (2015) who found that 89.43% of the analogies were concrete-concrete.

The finding showed that, based on the level of enrichment 43.59% analogies were simple analogies, 38.46% were enriched analogies and 17.95% were extended analogies. This shows that authors were not able to effectively explain abstract concepts by using more enriched and extended analogies. Considering the abstract nature of chemistry concepts, the authors should use more of enriched and extended analogies to explain chemistry concepts to increase students understanding. This is in line with Sendur et al (2011) who stated that widened or expanded analogies should be used instead of simple analogies. This is also in line with Ahmed et al (2015) who stated that it is worthwhile to include more of extended and enriched analogies in science textbooks since these two often

explain the relationships that exist between analogue and the target and also reduces level of misconception learners might have.

None of the Sampled Chemistry Textbooks made mention of the term analogy in their textbooks. Not prefixing the analogies with the term 'analogy', 'analogous' can lead to students learning the wrong concepts since the learners might perceive the idea wrongly. This might be as a result of the fact that the authors might not have had adequate knowledge about analogies or used the analogies unconsciously without actually knowing they are using it. This is in line with the assumption and findings of Jeongho et al (2004) who stated that the term analogy was rarely mentioned as analogies and are explicitly identified as analogies only about 15% of the time. This showed that the authors of the textbooks might be taking analogies to be the same thing as illustrations.

The finding showed that only one author states the limitation of the analogy used. By not stating the limitations of the analogies used, the authors might not have had adequate knowledge about the use of analogies. They might also be underestimating the difficulty that students will encounter when attempting analogical transfer between the analogue and target. This is in line with Jeongho et al (2004) who found out that extremely few analogies included description of limitations of the analogies. By not including limitations, students might end up taking the analogy for real concepts and this can bring about misinterpretation or misunderstanding among the learners.

The finding of the study also revealed that the analogies identified were substantially relevant to organic chemistry and appropriately used in explaining the concept

of organic chemistry in the selected textbooks. This shows that the authors are aware of the power of analogies in fostering understanding of abstract or difficult chemistry concepts. This is in line with the findings of Thiele (1991) who was of the opinion that those authors employing analogies more frequently in their texts tend to see analogies more as a motivational tool.

Conclusions

Based on the findings, the following conclusions were made. The study showed that chemistry textbook authors were familiar with analogies and also employ analogies in explaining abstract science concepts. The outcomes of this research further showed that the textbook authors mainly used functional, verbal, post synthesizer, concrete-abstract and simple analogies in presenting the concepts of organic chemistry in the selected chemistry textbooks. Only one author however stated the limitation of the analogy used and none of the authors precede the analogies with any statement indicating that it was an analogy. The identified analogies were relevant and appropriate in teaching and learning of organic chemistry. It was concluded that New School Chemistry for Senior Secondary Schools Textbook ranked the highest among the five textbooks.

Recommendations

Based on the findings and discussion, the following recommendations were suggested:

1. Textbooks authors should use analogies effectively in their texts as this will go a long way in explaining abstract concepts and make chemistry more meaningful to

the students. The authors should illustrate abstract concepts in ways that the readers can comprehend without the help of a teacher.

2. Textbook writers should continue to use pictorial-verbal analogies since it helps in meaningful learning and helps in retention of knowledge due to the fact that what one visualizes sticks better than written text.
3. The authors should continue to use structural analogies as this helps to concretize abstract concepts and bring about deeper understanding.
4. The authors should reduce the use of simple analogies and use more enriched and extended analogies to indicate all common attributes with the target concept.
5. The authors should indicate where analogies are used by prefixing the analogies with the term 'analogy', 'analogous' in order to avoid learning the wrong concepts since the learners might perceive the idea wrongly.
6. The authors should endeavor to state the limitations of the analogies in order to avoid misconceptions or alternative conceptions.
7. Authors should use more analogies in chemistry textbooks as it brings about meaningful learning by bridging the gap between familiar concepts and the unfamiliar ones. Chemistry being a broad subject needs literary tools like analogies to make it meaningful and interesting. The implication of this finding is that students can readily contact their textbooks in order to gain better knowledge about abstract science concepts when the teachers are not around to explain such difficult concepts.

Suggestions for further studies

In the light of the findings of this study, the following were recommended for future research.

1. This present study used Senior Secondary School textbooks. Future studies could improve on this by using tertiary institution chemistry textbooks and Junior secondary school textbooks in other subjects and domain, so as to allow for generalization.
2. Future studies could consider other topics in chemistry and other literary tools like metaphor which could account for the differential results should be studied.

REFERENCES

Ababio, O. Y. (2016). New School Chemistry for Senior Secondary Schools. Onitsha: Africana First Publishers PLC, Onitsha, Nigeria.

Abimbola, I. O. (2013). Philosophy of Science for Degree Students. Ilorin: Bamitex Printing and Publishing Enterprises.

Ahmed, M. A., Sulaiman, M. M., & Adeoye, G. A. (2015). Critical analysis of analogies related to evolution in selected biology textbooks used in Nigerian Secondary Schools. *Al-Hikmah Journal of Education*, 2(2), 1-18.

Akwara, U. C. (2017). The causes of student failure in National Examination and the adopted solution in Nigeria. *International Journal for Innovative Research in Multidisciplinary Field*, 3(10), 131-137.

Amoke, M. K. (2020). Analysis of Students' Performance in Chemistry in the West African Senior School Certificate Examination (WASSCE) and National Examination Council (NECO) from 2015-2018. *International Journal of Research and Analytical Reviews*, 7(1), 35-49.

Ayinde, F.O. & Asubiojo, F.O. (2011). Lamlad's SSCE & UTME CHEMISTRY. Ekiti: Lamlad Publications LTD, Ekiti, Nigeria.

Badmus, O. T., & Omosewo, E. O. (2018). Improving Science Education in Nigeria: The role of key Stakeholders. *European Journal of Health and Biology Education*, 1-5. Retrieved from https://www.researchgate.net/figure?Candidates-Enrolment-and-performance-in WASSCE-in-Biology-Chemistry-and-Physics_tbl1_324533974.

Bektas, O. (2017). Pre-Service Science Teachers' Pedagogical Content Knowledge in the Physics, Chemistry, and Biology Topics. *European Journal of Physics Education*, 6(2), 41-53.

Bello, G. & Abimbola, I. O. (2012). Gender Influence on Biology Students' Concept Mapping Ability and Achievement in Evolution.

Bradford, A., & Hamer, A. (2022). What is Science? Live Science https://www.livescience.com/20896-science-scientific-method.html. Retrieved January 17th, 2022.

Chu, C. K., & Hong, K. Y. (2010). Misconceptions in the teaching of chemistry in secondary schools in Singapore & Malaysia. Proceedings of the Sunway Academic conference 2010, 1-10.

Cunha, M., & Justi, R. (2009). European Science Education Research Association 2009, Istabul, Turkey.

Demehin, A.A., Onianwa, P.C., Oshinyemi, P.A., & Thomas, S. (2011). Macmillan Chemistry for Senior Secondary Schools. Lagos: Macmillan Nigeria Publishers Limited, Lagos, Nigeria.

Demircioglu, G., & Demircioglu, H. (2013) An investigation of Chemistry teachers' understanding of chemical equilibrium. *International Journal on New Trends in Education and Their Implications*, 4(2):192-199.

Duit, R. (1991). On the role of analogies and metaphors in learning science. *Science Education*, 75(6), 649– 672.

Duit, R., Roth, W., Komorek, M. & Wilbers, J. (2001). Fostering conceptual change by analogies – between Scylla and Charybdis. *Learning &Instruction*, 11(4), 283-303.

Dunbar, K. (2001). The analogical paradox: why analogy is so easy in naturalistic settings, yet so difficult in psychological laboratory. In D. Gentner, K. J., Holyoak, B. N., Kokinov (Eds.). *The analogical mind: Perspectives from cognitive science* (pp313-334). Cambridge, Massachusetts: The MIT press.

Efe, M. O. & Augustine, O. U. (2016). An analysis of misconceptions in organic chemistry among selected senior secondary school students in Zaria Local Government Area of Kaduna State, Nigeria. *International Journal of Education and Research*, 4(7), 247-266.

Gero, S. M. (2011). *The relationship between students' achievement in the theoretical and practical aspects of senior school certificate mock examination in chemistry*. Nsukka: M.Ed Dissertation submitted at Department of Science Education, University of Nigeria Nsukka, Nsukka, Nigeria.

Gilbert, S. W. (2009). An evaluation of the use of analogy, simile, and metaphor in science texts. *Journal of Research in Science Teaching*, 26(4), 315-327.

Glynn, S. M. (1991). Explaining Science concepts: A teaching-with-analogical model. In S.M. Glynn, R.H. Yeany and B.K. Britton (Eds.), *The Psychology of Learning Science* (pp. 219-240). Hillsdale, NJ: Erlbaum.

Glynn, S. M., Britton, B. K., Semrud-Clikeman, M., & Muth, K. D. (1989). Analogical Reasoning and problem solving in science textbooks. In Glover J. A., Ronning, R.

R., & Reynolds, C. R. (Eds.). *A handbook of creativity: Assessment, research and theory*. New York: Plenum.

Guler, P. D., & Yagbasan, R. (2008). The description of problems relating to analogies used in science and technology textbooks. Inonu University, *Journal of the Faculty of Education*, 9(16), 105-122.

Hornby, A. S. (2015). *Oxford Advanced Learner's Dictionary 9th Edition*. UK: Oxford University Press.

Ibe, J. O., & Umoren, G. (2009). Misconceptions of concepts in chemistry among senior secondary school teachers in Cross River State, Nigeria. *Annals of Modern Education*, 1(1), 139-147.

Ifedili, C. J., & Ojogwu, C. N. (2007). An appraisal of globalization and Nigerian Educational policies. Retrieved from http://findarticles.com/p/articles/mi_qa3673/is_1128/ai_n29381535/pg_2/.

James, M. C., & Scharmann, L. C. (2007). Using analogies to improve the teaching performance of preservice teachers. *Journal of Research in Science Teaching*, 44(4), 565-585.

Jeongho, C., Soonhwa, B., & Taehee, N. (2004). The analysis of analogies in chemistry content of Secondary School Science Textbooks based on the 7th National Curriculum. *Journal of the Korean Chemistry Society*, 48(6), 629-640.

Johnstone, A. H. (1993). The development of chemistry teaching. *Symposium on Revolution and Evolution in Chemical Education*, 70(9):701-705.

Johnstone, A. H. (2000). Teaching of Chemistry-logical or psychological? *Chemistry Education: Research and Practice in Europe*, 1(1):9-15.

Justi, R., & Mozzer, B. N. (2009). European Science Education Research Association 2009, Istabul, Turkey.

King, C. J. (2010). An Analysis of Misconceptions in Science Textbooks: Earth Science in England and Wales. *International Journal of Science Education*, 32(5), 565-601.

Kwara State Ministry of Education and Human Capital Development (2022). 2021-2024 Approved List of Books for Senior Secondary Schools 1-3.

Lewis, J. R. (1933). Analogies in teaching freshman chemistry. *Journal of Chemical Education*, 10, 627-630.

Moodley, K., & Gaigher, E. (2019). Teaching Electric Circuits: Teachers' Perceptions and Learners' Misconceptions. *Research in Science education*, 49(1), 73-89.

Musa, U. & Ilknur, C. (2019). Misconception in Chemistry Education and Practices to Eliminate Them: Literature Analysis. *Journal of Education and Training Studies*, 7(3), 202-208. doi:10.11114/jets.v7i3.3990.

National Open University of Nigeria (2015). (N.D.). PHS 201: Anatomy. National Open University of Nigeria. Victoria Island: Lagos State. Ronea Press Limited.

National Research Council. (1997). Science Teaching Reconsidered: A Handbook. National Academics Press. Retrieved from https://www,nap.edu/catalog/5287/science-teaching-reconsidered-a-handbook.

Nelson, P. G. (2003). Basic Chemical Concepts. *Chemistry Education Research and*

Practice, 4(1), 19-22.

Nigerian Educational Research and Development Council (NERDC), Federal Ministry of Education (2007). Senior Secondary Education Curriculum Chemistry for SS1-3, 2007.

Nbina, J. B. (2012). Analysis of Poor Performance of Senior Secondary Students in Chemistry in Nigeria. *International Multidisciplinary Journal, Ethiopia*. 6(4), 324-334.

Odesina, I. A. (2020). Essential Chemistry for Senior Secondary Schools. Ibafo: Tonad Publishers Limited, Ibafo, Nigeria.

Ojokuku, G. O. (2019). Understanding Chemistry for Schools and Colleges. Zaria: Press-on Chembooks, Zaria, Nigeria.

Olayemi, O. E. (2021). Analysis of analogies related to nervous coordination in selected biology textbooks commonly used in Nigeria. Ilorin: BSc. Ed. Research work submitted at Department of Science Education, University of Ilorin, Ilorin, Nigeria.

Onasanya, F. T. (2013). *Analysis and description of analogies used in presenting genetics in senior school biology textbooks in Nigeria*. Ilorin: M.Ed. Dissertation submitted at Department of Science Education, University of Ilorin, Ilorin, Nigeria.

Orgill, M., & Bodner, G. (2004). What research tells us about using analogies to teach chemistry. *Chemistry Education Research and Practice*, 5(1), 15-32.

Riskiani, Y. R., & Hari, S. (2019). The Analysis of Analogy use in Chemistry Teaching.

International Seminar on Science Education. IOP Conf. Series: Journal of Physics: Conf. Series 1233 (2019) 012022, doi:10.1088/1742-6596/1233/1/012022.

Sarantopoulos, P., & Tsaparlis, G. (2004). Analogies in chemistry teaching as a means of attainment of cognitive and effective objectives: A longitudinal study in a naturalistic setting, using analogies with a strong social content. *Chemistry Education Research and Practice*, 5(1), 33-50.

Sendur, G., Toprak, M., & Sahin-Pekmez, E. (2011). An analysis of analogies used in secondary chemistry textbooks. *Procedia Computer Science* 3, 307–311. www.elsevier.com/locate/procedia.

Soeharto, B. C., Sarimanah, E., Dewi, F. I., Sabri, T. (2019). A review of students' common misconceptions in science and their diagnostic assessment tools. Jurnal Pendidikan IPA Indonesia, http://journal.unnes.ac.id/index.php/jpii, 8(2), 247-266.

Statistics Section of the WAEC Office Yaba, Lagos (2017) Candidates' Enrolment and performance in May/June WASSCE in Biology, Chemistry and Physics in Nigeria from year 2007 to 2016.

Thiele, R.B., & Treagust, D. F. (1994). An interpretive examination of high school chemistry teachers' analogical explanations. *Journal of Research in Science Teaching*, 31, 227-242.

Thiele, R.B., & Treagust, D. F. (2004). The nature and extent of analogies in secondary chemistry textbooks. *Instructional Science*, 22(1),61-74.

Thiele, R.B., & Treagust, D. F. (2010). Eric Document Reproduction, Service No: ED 357 966, (1992). Retrieved January, 2010. http://www.springerlink.com/content/q1117 t5h 8t1240ml/.

Topal, G., Oral, B., & Ozden, M. (2007). University and Secondary school students' misconceptions about the concept of aromaticity in organic Chemistry. *International Journal of Environmental and Science Education,* 2, 135-143.

Treagust, D. F., & Chittleborough G. (2001). Chemistry: A matter of understanding representations, In Brophy, J. (ed.). *Subject-Specific instructional methods and activities*, Elsevier Science Ltd., Amsterdam, Neitherlands.

University of Wisconsin La Crosse (2022) Why study Chemistry? https://www.uwlax.edu/chemistry-and-biochemistry/student-resources/why-study-chemistry/. Retrieved January 23rd, 2022.

WAEC, (2019). General Resume of The Chief Examiners' Reports for The West African Senior School Certificate Examination for School Candidates.

Yener, D. (2012). A study on analogies presented in high school Physics textbooks. Asia-Pacific Forum on Science Learning and Teaching,13(1), 1-18.

APPENDIX I

UNIVERSITY OF ILORIN, ILORIN, NIGERIA

DEPARTMENT OF SCIENCE EDUCATION

HEAD OF DEPARTMENT
Dr. Khadijat S. Ameen
B.Sc. (Ed), M. Ed., Ph.D. (Ilorin)

P.M.B 1515, Ilorin, Nigeria
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Our Ref: UIL/SCIEDU/87

Your Ref:

Date: 15/11/2022

LETTER OF INTRODUCTION

The bearer of this letter Ogunlakin Grace Odunayo (17/25PB090) is a undergraduate student in the Department of Science Education, University of Ilorin, Ilorin, Nigeria. He/She is conducting a research study as part of the requirement for the award of Bachelor of Science in Education B. Sc.(Ed.) Degree.

The title of the Study is Analysis of Analogies used in Solving Students' Misconceptions in some Selected Senior Secondary School Chemistry Textbooks in Nigeria.

Kindly allow your students/teachers to participate in the study. Be assured that the researcher has addressed all ethical issue arising from the research design.

Thank for your usual cooperation.

15/11/2022
Project Supervisor

17/11/2022
Ag. Head of Department

APPENDIX II

UNIVERSITY OF ILORIN

PMB 1515, ILORIN, NIGERIA.

FACULTY OF EDUCATION

DEPARTMENT OF SCIENCE EDUCATION

RESEARCH ON

ANALYSIS OF ANALOGIES USED IN SOLVING STUDENTS' MISCONCEPTIONS IN SOME SELECTED SENIOR SECONDARY SCHOOL CHEMISTRY TEXTBOOKS IN NIGERIA.

Dear Sir/Ma,

The purpose of this research is to identify and analyze analogies used in solving students' misconceptions in some selected Senior Secondary School Chemistry Textbooks in Nigeria.

I, Ogunlakin Grace Odunayo with Matric Number 17/25PB090 humbly request from the Directorate of School Services, Ministry of Education for the recommended List of Chemistry Textbooks used in Senior Secondary Schools in Ilorin, Kwara State. The list of textbooks will be used for the purpose of this research work and the information shall be treated with utmost confidentiality.This will enable the researcher to carefully analyse the use of analogies to explain the abstract chemistry concepts in the textbooks for easy understanding.

The findings of this research will encourage the textbook authors to use relevant and appropriate analogies to elaborate abstract chemistry concepts in the textbooks. It will also help both teachers and students to pay more attention in the use of analogies to explain difficult and abstract chemistry concepts in the textbooks.

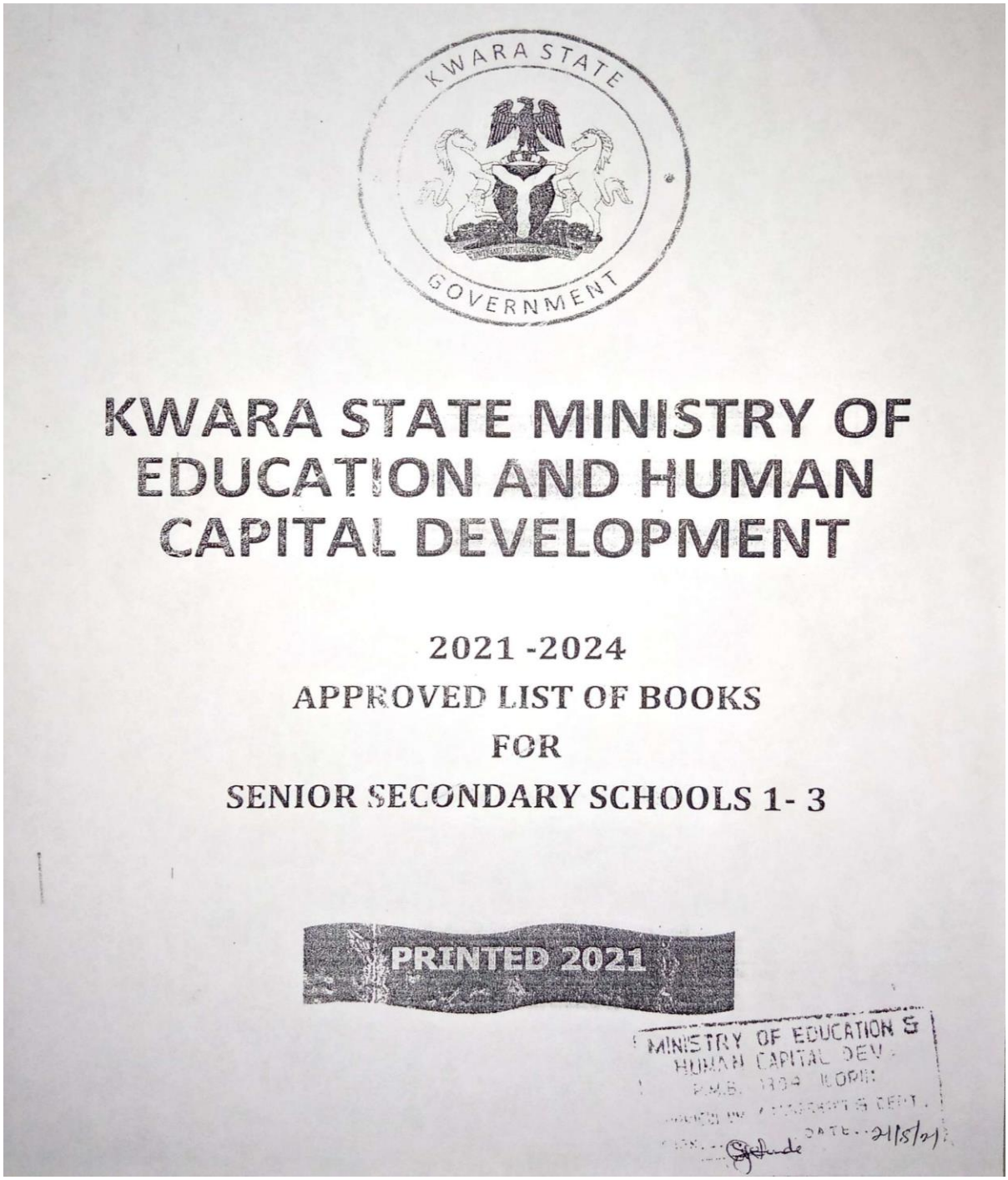
Yours faithfully

Ogunlakin Grace Odunayo

17/25PB090

FOR HON. COMMISSIONER
MINISTRY OF [illegible]
HUMAN C. [illegible]
P. M. B. [illegible]
KWARA STATE, NIGERIA
SIGN. ... DATE 17/11/22

APPENDIX III



1.07 CHEMISTRY

TITLE OF THE BOOKS	AUTHOR(S)	PUBLISHER	YEAR
Macmillan Chemistry for SSS	A. A. Ademehin et 'al	Macmillan	2011
Fresh Concept Chemistry	Stephen Afolayan et 'al	Fresh Pub	2021
Comprehensive Certificate Chemistry	GNCOHIA et 'al	UPL	2016
New School Chemistry	Oseiyaw Ababio	AFP Plc	2020
Complete Chemistry for SSS	F. Barter et 'al	Pearson	2014
Essential Chemistry	Odesina I. A	Tonad Pub	2018
Excellence in Chemistry	A. I Oluwaseun et 'al	Cambridge University Press	2016
Functional Chemistry	Plus O. Ukoha	Nelson	2020
Senior Seconary School Chemistry	S. T. Bajah et 'al	Learn Africa	2012
Effective Chemistry for SSS	Victor O. Njoku et 'al	Evans Brothers	2018
Extensive Chemistry for SSS & Coll.	Tijani Olarewaju I.	Extension Pub	2020
SUPPLEMENTARY			
Progressive in Chemistry	Adeyemi Femi O. et 'al	Rasmed	2020
CALCULATION IN CHEMISTRY			
Bounty Calculations in Chemistry	Charles A. Asemota et 'al	Bounty	2018
Calculations in Chemistry	Oyebanji A. O. et 'al	Jide Pub	2019
Calculation in Chemistry	Benerd B. Akintelure	Thursmay	2020
Chemistry Assessment	Adeyemo O. Esther	Seagull Pub	2018
PRACTICAL CHEMISTRY			
Practical Chemistry	B. B. Akintelure	Longman Nig Plc	2007

FOR HON COMMISSIONER
MINISTRY OF EDUCATION &
HUMAN CAPACITY DEVELOPMENT
P. M. B 1390 ILORIN
KWARA STATE, NIGERIA
SIGN ..... DATE 17/11/22