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FACTORS INFLUENCING UAE HIGH SCHOOL CHEMISTRY STUDENTS' LEARNING OF ORGANIC QUALITATIVE ANALYSIS: A QUALITATIVE STUDY

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This dissertation is submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Science Education

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Cover: Image related to factors influencing UAE High School Chemistry students' learning of OQA

(Photo: By Manal Almahdawi)

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Declaration of Original Work

I, Manal Almahdawi, the undersigned, a graduate student at the United Arab Emirates University (UAEU), and the author of this dissertation entitled "*Factors Influencing UAE High School Chemistry Students' Learning of Organic Qualitative Analysis: A Qualitative Study*", hereby, solemnly declare that this is the original research work done by me under the supervision of Prof. Ahmad Qablan, in the College of Education at UAEU. This work has not previously formed the basis for the award of any academic degree, diploma or a similar title at this or any other university. Any materials borrowed from other sources (whether published or unpublished) and relied upon or included in my dissertation have been properly cited and acknowledged in accordance with appropriate academic conventions. I further declare that there is no potential conflict of interest with respect to the research, data collection, authorship, presentation and/or publication of this dissertation.

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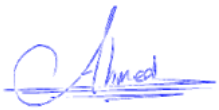
   Signature _____ __  _____ Date 21/06/2024

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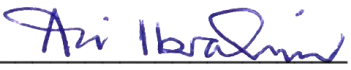
Signature 

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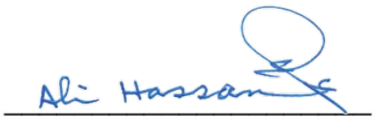
Signature 

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Abstract

Chemistry is one of the five science subfields typically covered in secondary schools in the United Arab Emirates. Chemistry is a branch of science that studies substances' characteristics, components, and structures. Numerous subfields fall under the umbrella of chemistry, including inorganic, organic, analytical, and physical chemistry. One of the topics covered in chemistry classes is the analysis of chemical compounds, which is divided into two types: quantitative analysis and qualitative analysis. While qualitative analysis determines the kind of each element or group present in a given solution sample, quantitative analysis determines the quantity of each element or group present. Students' low achievement and poor chemistry performance are significant issues plaguing education in the UAE. For example, in PISA 2018, the average performance in science of 15-year-old UAE students was 434 points, compared to an average of 489 points in OECD countries. Furthermore, the average performance in science of 8-Grade UAE students is 473 points, which is below the scale center- point of 500 points. In this context, this study aims to identify the factors influencing 12th grade UAE school students' learning of an essential Chemistry concepts (OQA). A qualitative research approach was used to gain an in-depth understanding of the factors responsible for the difficulties UAE students in grade 12 encounter while studying OQA topics in Chemistry. Three qualitative data collection instruments were used; students' observations, participants' interviews, and document analysis of students' study journals, notebooks, and worksheets. Thematic analysis was then utilized to examine the students' conceptual understanding of the topic using the qualitative data gathered. The results highlighted challenges within teaching OQA in chemistry including resource constraints impacting practical instruction, curriculum-content misalignments, instructional method deficiencies, and teacher motivation issues. Recommendations include overcoming these challenges through incorporation of practical based approaches, enhancing resource availability, aligning the chemistry curriculum with instructional practices and improving PD (professional development), with offering support to both instructors and 12th grade students to drive a more effective learning environments in chemistry education.

Keywords: Organic qualitative analysis, functional groups, student understanding, UAE, grade 12 students.

Title and Abstract (in Arabic)

العوامل المؤثرة في تعلم طلاب الكيمياء في المدارس الثانوية بدولة الإمارات العربية المتحدة للتحليل النوعي العضوي: دراسة نوعية

الملخص

الكيمياء هي واحدة من المجالات العلمية الفرعية الخمسة التي يتم تناولها عادة في المدارس الثانوية في دولة الإمارات العربية المتحدة. الكيمياء هي فرع من فروع العلوم التي تدرس خصائص المواد ومكوناتها وبنيتها. تندرج العديد من المجالات الفرعية تحت مظلة الكيمياء، بما في ذلك الكيمياء غير العضوية، والعضوية، والتحليلية والفيزيائية. أحد المواضيع التي تتناولها دروس الكيمياء هو تحليل المركبات الكيميائية، وهو ينقسم إلى نوعين: التحليل الكمي والتحليل النوعي. بينما يحدد التحليل النوعي نوع كل عنصر أو مجموعة موجودة في عينة معينة، يحدد التحليل الكمي كمية كل عنصر أو مجموعة موجودة في نفس العينة. يعد انخفاض تحصيل الطلاب وضعف أداءهم في الكيمياء من المشكلات المهمة التي يعاني منها التعليم في دولة الإمارات العربية المتحدة .على سبيل المثال، في برنامج التقييم الدولي للطلاب 2018 (PISA)، بلغ متوسط الأداء في العلوم للطلاب الإماراتيين البالغين من العمر 15 عامًا 434 نقطة، مقارنة بمتوسط 489 نقطة في دول منظمة التعاون الاقتصادي والتنمية (برنامج التقييم الدولي للطلاب في الإمارات العربية المتحدة، 2018). علاوة على ذلك، يبلغ متوسط الأداء في العلوم لطلبة الصف الثامن في دولة الإمارات العربية المتحدة 473 نقطة، وهو أقل من نقطة المقياس المركزية البالغة 500 نقطة .

وفي هذا السياق، تهدف هذه الدراسة إلى تحديد العوامل المؤثرة على تعلم طلاب الصف الثاني عشر في المدارس الإماراتية لمفاهيم الكيمياء الأساسية (OQA). تم استخدام منهج البحث النوعي للحصول على فهم متعمق للعوامل المسؤولة عن الصعوبات التي يواجهها طلاب دولة الإمارات العربية المتحدة في الصف الثاني عشر أثناء دراسة مواضيع OQA في الكيمياء. تم استخدام ثلاث أدوات لجمع البيانات النوعية؛ ملاحظات الطلاب، ومقابلات المشاركين، وتحليل المستندات الخاصة بمجلات دراسة الطلاب، ودفاتر الملاحظات، وأوراق العمل. ثم تم استخدام التحليل الموضوعي لفحص الفهم المفاهيمي للطلاب باستخدام البيانات النوعية التي تم جمعها. سلطت النتائج الضوء على التحديات في تدريس OQA في الكيمياء بما في ذلك: قيود الموارد التي تؤثر على التدريس العملي، واختلال محتوى المنهج، وأوجه القصور في أساليب التدريس، وقضايا تحفيز المعلمين. وتشمل التوصيات التغلب على هذه التحديات من خلال دمج الأساليب العملية، وتعزيز توافر الموارد، ومواءمة منهج الكيمياء مع الممارسات التعليمية وتحسين التطوير المهني، مع تقديم الدعم لكل من المعلمين وطلاب الصف الثاني عشر لقيادة بيئات تعليمية أكثر فعالية في تعليم الكيمياء.

مفاهيم البحث الرئيسية :التحليل النوعي العضوي، المجموعات الوظيفية، فهم الطلاب، دولة الإمارات العربية المتحدة طلاب الصف الثاني عشر

Author's Contribution

The contribution of Manal Almahdawi to the dissertation was as follows:

I. Contributed to the planning phase, took primary responsibility for data collection, processing, and evaluation of results.

II. Engaged in the planning stage, with primary responsibility for conducting experimental work, as well as data collection, processing, and evaluation of results utilizing NVivo computer software.

III. Held sole responsibility for both planning the research and conducting the experiments, including data collection, processing, and evaluation, facilitated by the use of NVivo computer software.

Author Profile

Manal Almahdawi is a dedicated and adaptable professional committed to student development and fostering engaging learning environments. With expertise in curriculum design, differentiated instruction, and student motivation, she employs innovative teaching strategies to meet diverse student needs. AlMahdawi is skilled in building strong relationships with students, staff, and parents to create a supportive school community as she works head of science department. She holds a Ph.D. candidacy in Curriculum and Instruction (Science Education), along with an M.Ed. in General Education and a BS in Chemistry. AlMahdawi has published articles in reputable journals and is experienced in classroom management, student assessment, and multicultural awareness. She has contributed to the field through her published articles, including 'High school students' performance indicators in distance learning in chemistry during the COVID-19 pandemic', which was published in Education Sciences. Additionally, her work on "Science Teachers' Awareness and Application of Bloom's Taxonomy in Online Assessment during the Covid-19 Pandemic" is currently under review for publication in the Journal of Research in Science Teaching.

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Dedication

To my beloved parents and family

Table of Contents

List of Tables

List of Figures

List of Abbreviations

CAQDAS	Computer-Assisted Qualitative Data Analysis Software
EmSAT	The Emirates Standardized Test
MOE	Ministry of Education
NGSS	Next Generation Science Standards
OQA	Organic Qualitative Analysis
PISA	Programme for International Student Assessment
TIMSS	Trends in International Mathematics and Science Study
WAEC	West African Examinations Council

Chapter 1: Introduction

Secondary schools in the United Arab Emirates typically cover all five-science subfields and chemistry is one of those subfields. Chemistry is included in the curriculum of secondary school students in the UAE, where it is considered a part of general science (Balfakih, 2003). Chemistry is a scientific discipline that focuses on the study of the characteristics, components, and structures of substances, as well as the transformations that these substances go through. In addition, numerous subfields fall under the umbrella of chemistry, including inorganic, organic, analytical, and physical chemistry (Anim-Eduful & Adu-Gyamfi, 2022).

The studies of the properties, structure, and reactions of compounds that contain the element carbon are referred to as organic chemistry. This type of chemistry (organic chemistry) excluding metallic carbonates like sodium carbonate (Na_2CO_3) and potassium cyanide (KCN), as well as carbon oxides like carbon dioxide (CO_2), are considered to be inorganic (Bettelheim et al., 2012).

To be successful in chemistry, students need to be able to deal with the subject's concepts at both the macroscopic and the sub-microscopic levels, as well as be able to link the symbolic representations that are used on each of these scales on these three levels—macroscopic, microscopic, and symbolic (Gabel, 1993). Students learn about microscopic and symbolic representations in the lecture before experiencing the macroscopic level in the lab. Macroscopic and microscopic representations can easily be connected through symbolic representations.

However, this ability is not usually achieved by students. Students, on average, have difficulty transitioning between representations and understanding how they are connected (Gabel, 1998). If a student does not fully comprehend the symbolic language being taught, he/she will likely have difficulty learning the material, which will lead to a disconnect between the student’s experience of the real world and his/her understanding of theoretical constructs (Anim-Eduful & Adu-Gyamfi, 2022).

Chemistry is important not only to students but also to members of the general public who are interested in learning more about chemicals (Hassan, 2017). The chemistry

subject gives students a more comprehensive understanding of science in general and is a required reading for anyone who wants to pursue education in fields related to the environment or climate change (Hassan, 2017).

Learning about the analysis of chemicals is one of the most significant aspects of studying chemistry. Both quantitative and qualitative analyses are the two subfields that together make up the field of chemical analysis. The difference between qualitative and quantitative analysis is that qualitative analysis determines which elements are present in the solution, whereas quantitative analysis determines the number of elements in the solution. The term "qualitative analysis" can then be subdivided further into two distinct subcategories, namely "organic qualitative analysis" and "inorganic qualitative analysis".

Aliphatic hydrocarbons, comprising saturated and unsaturated aromatic compounds such as amides, alkanols, alkenones, alkanols, alkyl alkanoates, and alkanoic acids, are the subject of qualitative organic analysis. This analytical approach primarily involves the detection of functional groups. During the initial stages of organic chemistry, the utilization of OQA emerged as a crucial methodology for ascertaining the structural characteristics of substances. Students may improve their knowledge of fundamental concepts relating to the structure and reactivity of organic compounds if they conduct chemical tests on functional groups (Adu-Gyamfi & Anim-Eduful, 2022).

In the OQA, the presence of functional groups in the solution is a priority. In contrast, in the inorganic qualitative analysis, the central theme is the detection of positive and negative ions and gaseous components in the solution—the determining and elucidating the structures of unidentified substances based on organic chemistry. To identify functional groups of unknown substances, chemists, for example, apply a qualitative picture of reactivity, which is instrumental in drug analysis.

Back in the days of the development of organic chemistry, qualitative analysis was an essential tool used to define chemical structures. Qualitative reactivity patterns are among the most essential techniques chemists often rely on for examining the functional groups of unknown compounds in drugs. In the pioneering period of organic chemistry, this technique, generally called qualitative analysis, was of great importance in the structural determination of the chemical species (Fieser & Williamson, 1992).

1.1 Chemistry in the UAE Schools

Grade 10th students in the United Arab Emirates have chemistry as an individual subject. In this stage, students must select a science course covering math, chemistry, physics, biology, and geology if they wish to continue with science during high school. Intake of the students and unsatisfactory results of chemistry classes at the high school level represent a problem that disturbs education in the UAE. This is much more serious in secondary school (Ridge et al., 2017). For instance, UAE students' science average score in PISA 2018 is 434 compared to the average score of 489 in OECD countries (Mullis et al., 2020). Another example, TIMSS 2019, the average science performance of Grade 8 students in UAE is 473, which is less than the median point of scale (Mullis et al., 2020).

One of the reasons that can lead to continuous failure by the 12th grade students in chemistry in UAE is their attitude towards practical sessions, the amount of commitment they have in learning chemistry, the resources they have to support this particular lesson, or the relations they have with other students considering how they collaborate and how they attend their classes (Nja et al., 2019). On the opposite side, there is also a profound tendency in the literature to reflect on the mechanisms that affect students' chemistry grades. Thus, as one of the most indicative factors of students' success in chemistry classes in the UAE, the students' performance and results should be studied very thoroughly.

Relevant literature show that Emirati students struggle to correctly identify the functional group as well as the correct number and position of multiple bonds in organic molecules (Malkawi et al., 2018). Based on students' feedback, organic chemistry is a difficult subject that places a strong emphasis on memorization and has a great deal of information that needs to be absorbed (Anim-Eduful & Adu-Gyamfi, 2022). Therefore, the aim of this study is to identify the factors that influence UAE school students' learning and performance in chemistry, ascertain the extent of the subject's performance, and propose potential solutions that could be implemented to address these issues. Furthermore, the study tries to Enhance UAE students' performance in international examinations like TIMSS and PISA.

1.2 Qualitative Analysis of Organic Compounds in Chemistry Curriculum

According to Al Zarooni (2014) most scientific ideas revolve around the structure of matter, making chemistry an essential subject for any science student. Therefore, chemistry provides a thorough understanding of matter's molecular makeup, making it a vital topic for high school. There are two main approaches to studying chemical compounds in chemistry: quantitative (volumetric) analysis and qualitative analysis. Both aim to provide a better understanding of the structure of matter.

Matthews (2011) states that quantitative analysis finds the amount of each element or group in a solution sample, whereas qualitative analysis finds the sort (or types) of elements or groups present. The field of qualitative organic analysis focuses on the detection of functional groups, namely aliphatic hydrocarbons (alkanes, alkenes, and benzene) and carbonyl compounds (aldehydes, ketones, and alkanones), as well as amides, alkanoic acids, alkyl alkanoate, and alkanoic acids (Buthelezi et al., 2020, p. 658).

What gives an organic complex its unique chemical features are its functional groups, which are atoms or groups of bound atoms. The functional groups covered in senior high school qualitative analysis of organic compounds in chemistry UAE curriculum and classes include alcohols (-OH), aldehydes (-CHO), ketones (-C = O), carboxylic acids (-COOH), esters (-COO), amides (-CONH2), & hydrocarbons, which include aliphatic hydrocarbons (alkanes, alkenes, & alkynes) and aromatic hydrocarbons (benzene) (Buthelezi et al., 2020, p.697).

Essential parts of the UAE organic chemistry curriculum in high school, especially in grade 12, are identifying and characterizing unknown substances' structures instance, alkene and alkyne are unsaturated hydrocarbons that their reaction can identify with Br_2 in water. The visible proof of a reaction, in the form of the reddish-brown hue of bromine either fading away or completely disappearing, proves that the unidentified solution includes carbon double or triple bonds (Atkins & Beran, 1992).

Saturated hydrocarbons have only one single carbon bond and do not change the cold alkaline or acidified tetraoxomanganate (VII) ($KMnO_4$) solution's purple color in any discernible way. Neither Br_2 in tetrachloromethane (Br_2/CCl_4) nor bromine in H_2O Br_2/H_2O) reacts with alkanes (Atkins & Beran, 1992; Fieser & Williamson, 1992).

Due to weak and receptive bonds in their molecules, unsaturated hydrocarbons—hydrocarbons that contain a carbon-carbon double bond or a carbon-carbon triple bond—primarily undergo addition reactions (Schmid, 1996). According to Atkins and Beran (1992) and Fieser and Williamson (1992), the alkynes of an organic molecule may be found using the Bromine Test. In contrast, the alkenes can be identified using Baeyer's Test (Alkaline $KMnO_4$ Test).

In Baeyer's Test, the unsaturated hydrocarbon is mixed with alkaline $KMnO_4$, which causes the alkaline tetraoxomanganate (VII) ($KMnO_4$) solution to lose its pinkish-purple hue (Fieser & Williamson, 1992). The pinkish-purple hue fades when the brown precipitate of MnO2 forms. This is because oxidation state (O.S) of manganese has changed from +7 to +4. Tetraoxomanganate (VII) ($KMnO_4$) solution's purple color begins to fade as a result of manganese's transition from a +7 to a +2- oxidation state (Fieser & Williamson, 1992).

A reddish-brown tint in a solution of carbon tetrachloride (Br_2/CCl_4) or bromine water (Br_2/H_2O) is eliminated or rendered colorless in the Bromine Test when an unsaturated organic component is added to bromine (Atkins & Beran, 1992).

1.3 Qualitative Analysis of Organic Compounds in Chemistry Teaching and Learning

Science educators have emphasized the importance of improving conceptual understanding of scientific concepts & processes, but many teachers neglect instructional strategies. As a result, many students still have misconceptions after leaving chemistry classrooms. The teachers must spend time and effort in instructional strategies that promote conceptual change. However, the practice of chemistry instruction has placed a strong emphasis on the memorization of numerous chemistry concepts (Chin, 2004).

To help students better understand functional groups in OQA and avoid common misunderstandings, Akkuzu and Uyulgan (2016) suggested using activity-based lessons to reinforce basic chemistry concepts, build on students' existing knowledge, and introduce new material. Results from the study by Asghar, Huang, Elliot, and Skelling (2019) show that students better comprehend common scientific ideas when their teachers employ well-planned instructional activities.

Teachers can better address their students' alternative ideas when they employ suitable inquiry-based activities in chemistry classes. The study conducted by Adu-Gyamfi et al. (2017) revealed several significant findings. One of these is that when chemistry classes are not taught using effective and appropriate methods, students lose interest in the subject, and teachers cannot foster an environment that encourages innovation, creativity, and investigative learning.

Chemistry classes, especially those focusing on OQA, are more engaging and productive when held in well-equipped classrooms with all the required chemicals. To make the ideas more approachable, chemistry professors should examine the process of detecting functional groups of organic compounds before instructing students in OQA using activity-based learning strategies. Regarding chemistry education in the United Arab Emirates (UAE), profile aspects characterize fundamental behaviors in the classroom, on the exam, and in life.

Teaching, learning, and testing in chemistry are characterized by three profile dimensions: knowledge and understanding, application & knowledge, and practical and experimental skills. Students can exhibit their ability to work with their hands and conduct experiments by utilizing various tools and equipment to solve real-world problems throughout inquiry processes. Promoting both subject knowledge and strategic learning techniques maximizes learning results (Conner & Gunstone, 2004).

The West African Examinations Council (WAEC) also sets the qualitative analysis questions for both theoretical and practical examinations. Qualitative analysis is a common topic for exam questions in academic and professional writing. Students are provided with organic compounds that possess different types of functional groups in theoretical papers. They should specify which functional groupings are present and explain how to conduct experiments to test them.

A vital component of the practical exams is having students do tests on anonymous samples. As part of their experiments, students must compile notes and conclude. The United Arab Emirates Ministry of Education (MOE) asserts that pupils who grasp qualitative analysis will have a more comprehensive understanding of chemistry as it supports previously taught theoretical concepts.

This study summarizes its findings by examining what factors impact UAE high school chemistry students' comprehension of the OQA. Using the qualitative research methods, the study provides in-depth insights into the challenges faced by students when studying this topic. The researcher assumes a significant role in data collection and analysis, according to Creswell (2017), interpreting the data from a qualitative perspective.

Researchers use a method called qualitative research to collect information. They do not use tools made by other researchers; instead, they collect data themselves " (Creswell, 2017; p. 38). The study identifies the elements that impact students' understanding of OQA and emphasizes the need to examine multiple achievement indicators among chemistry students in the UAE.

1.4 Organization

Chapter 1 mentions that the poor performance of 12th -grade students in chemistry in the UAE has been attributed to various factors, including learning approaches, motivation levels, availability of resources, teacher-student relationships, collaborative efforts, and attendance patterns (Nja et al., 2019). However, a more comprehensive understanding of the factors influencing students' chemistry performance is required. So, this study's goal is to find out what makes OQA a challenging chemistry topic for UAE high school students. The goal is to determine the barriers to students' understanding as well as their perceptions of OQA.

The literature in Chapter 2 highlights that Emirati students encounter difficulties in identifying functional groups and accurately determining the number and location of multiple bonds in organic molecules (Adu-Gyamfi et al., 2017). Additionally, they perceive organic chemistry as a challenging subject that requires extensive memorization (Anim-Eduful & Adu-Gyamfi, 2022). Therefore, this study intends to investigate the contributing factors that influence UAE school students' learning in chemistry, assess their performance in the subject, and propose potential solutions to address these difficulties. Furthermore, it aims to enhance the performance of UAE students in international exams such as TIMSS and PISA.

The literature review chapter also examines the factors influencing student achievement in Chemistry, including students' backgrounds, lack of interest, untrained

teachers, ineffective teaching methods, and insufficient learning materials (Hassan et al., 2017). Three barriers are identified: school-level, system-level, and teacher-level barriers, which can impact students' attitudes toward learning, opportunities for science teachers' professional development, their education, and student's performance in Chemistry (Hussain et al., 2017). These barriers include teachers' incompetence, lack of self-confidence, inadequate pedagogical and professional training, lack of differentiated training programs, outdated or poorly maintained lab equipment, lack of appropriate lab instruments, traditional educational systems, obstructive curricula, and limited organizational structures.

Chapter 3 outlines the plan to gather qualitative data from students regarding their understanding of OQA. The research questions focus on the factors influencing students' comprehension of OQA, the challenges they face in conceptualizing the topic, and the support they require for better understanding. This study recognizes the significance of improved performance in OQA. indicating a higher scientific understanding (Hassan et al., 2017). Qualitative data are collected through student observations, participant interviews, study journals and notebooks analysis, and other relevant documents related to teachers and students. Thematic analysis is employed to explore students' conceptual understanding of the topic. The results are examined in the context of existing literature to understand better the factors affecting learning in this area for senior high school students.

1.5 Problem Statement

Many people believe that chemistry is one of the most challenging science subjects to comprehend and the level of educational achievement in chemistry is not appealing to students as it is in other subjects (Cardellini, 2012). The rate of failure remains very high (Nja et al., 2019). As a result, it attracts the lowest number of students (Apu, 2020). Therefore, chemistry classes, including UAE classes, have fewer students enrolled than most other science subjects, especially at the grade 12 level. Specifically, numerous science researchers noted that students struggle to understand organic chemistry concepts (Anim-Eduful & Adu-Gyamfi, 2022). According to students, the concept of organic chemistry is considered to be an extremely difficult task to understand and hard to memorize with numerous ideas to learn (Bhattacharyya & Bodner, 2005).

Organic chemistry is the study of the structure, properties, reactions, and preparation of carbon compounds and the findings of previous studies revealed that students performed poorly in most organic concepts in organic chemistry, writing equations, remembering chemical formulae, doing calculations, and understanding chemical reaction equilibrium (Achor & Ukwuru, 2014). The concept of organic chemistry is essential because it is the study of all chemical reactions related to life. However, students show difficulties and face challenges learning it (Anim-Eduful & Adu-Gyamfi, 2022). These difficulties might lead students to develop a broad range of alternative concepts (Stieff, 2007).

The analysis of chemical compounds is an essential field of study, as it helps scientists understand the properties and behavior of different substances. This knowledge can be used to develop new drugs, materials, and other products and solve various scientific and technological problems.

A quantitative analysis can be done by finding the number or the amount of a particular chemical substance in a sample. This is mainly accomplished through titration, spectroscopy, or gravimetry. Through qualitative analysis methods, the traces of certain substances in objects are identified, and their chemical and physical properties are determined. The qualitative methods commonly used involve chromatography, spectroscopy, and chemical reactions.

To summarize, there are two main approaches to chemical compound analysis. One is qualitative analysis, which involves determining the kind of components or groups of elements in a solution sample. In contrast, quantitative analysis involves counting the quantity of each ingredient or set of components in a solution sample (Matthews, 2011).

Thus, the qualitative analysis of organic compounds may help students understand fundamental ideas related to the structure and reactivity of organic compounds (Anim-Eduful & Adu-Gyamfi, 2022). Despite the importance of the qualitative analysis of organic compounds in comprehending the structure and reactivity of organic compounds, students have challenges understanding it conceptually (Anim-Eduful & Adu-Gyamfi, 2022).

In line with the growing emphasis on students in the United Arab Emirates to be among the global best in reading, mathematics, and science and springing from "The National Agenda of the UAE", there is a growing need for a new approach to teaching and learning of these subjects including Chemistry and its essential concepts such as the qualitative organic analysis. It is of great importance for educators in the UAE to have a better understanding of the factors that may influence the teaching &learning of these concepts. Thus, this study attempted to shed light on factors that may influence 12th grade UAE students' learning of qualitative organic analysis.

The researcher has not found any previous research in the UAE that has used OQA to identify the variables that influence students' comprehension of the subject in 12th grade. It is believed that the findings of this study can be used as a foundation to improve students' understanding, which in turn, may serve as a guide for more effective chemistry lesson delivery. The results of this study also provide a window into the development of new pedagogical approaches and policies that can be implemented in the future to deal with crises that might occur in the educational system (Chen et al., 2020).

Additionally, this study looks into the challenges that chemistry students in senior high school face when learning OQA. The objective establishes what the students hope to gain from OQA classes, what they face as obstacles to learning, and what they anticipate from the courses themselves. Interviews are employed as a means of obtaining qualitative data from students. We conduct a more in-depth examination of the perspectives held by the participants about the instruction and learning of OQA. This is achieved through the refinement and elucidation of the qualitative data obtained from the students. An observation checklist is created using the results of the interviews with students.

1.6 Purpose of the Study

Finding out what makes OQA a challenging chemistry topic for UAE high school students is the driving force for this study. The goal is to determine the barriers to students' understanding as well as their perceptions of OQA. Interviews were used as a primary source to collect data from 12th grade chemistry students. The collected qualitative data from students were analyzed to delve deeper into students' perspectives on the learning of OQA Within the UAE context, few studies have focused on different levels of education

and analysis of different branches of chemistry. However, after a thorough review of the existing literature related to UAE, it appeared that there was no research that addresses the factors affecting grade 12th student understanding of OQA. Hence, this study is the first to focus on this topic.

1.7 Research Questions

This study is trying to answer the following questions:

I. What factors influence 12th grade UAE students' understanding of OQA?
II. What are the challenges that 12th grade students face in conceptualizing OQA and how to overcome these challenges?
III. What sort of support do 12th grade students need to better understand OQA?

1.8 Significance of the Study

The findings of this research are expected to inform the teaching and learning processes in the subject of OQA in UAE schools. Specifically, it is hoped that the findings will raise awareness among the academic and administrative staff about the factors that might have positive or negative effects on students' understanding of the OQA. Educational experts, policymakers, teachers, curriculum developers, and other concerned stakeholders may use the results of this research in implementing educational policies, innovative teaching strategies, and tailored programs to prepare teachers on ways to better teach the subject and help students understand it.

1.9 Research Gap

While studies explore OQA (Organic Qualitative Analysis) curriculum content and teacher perspectives, few investigate student experiences in depth. This gap hinders a holistic understanding of learning OQA. By investigating these questions, this study aims to address the identified gaps in the literature and provide valuable insights into OQA learning within the unique UAE educational context. This knowledge can inform curriculum development, teacher training, and ultimately, improve student learning outcomes in OQA.

1.10 Definition of Terms

a. OQA: Analyzing a solution sample qualitatively to determine the kind of each constituent or group (Matthews, 2011).
b. Functional groups: A variety of topics are covered in the qualitative organic examination, which essentially involves functional group detection. These include aromatic (benzene), saturated (alkanes), and unsaturated (alkenes, alkynes, and alkenes) hydrocarbons; alkanols; carbonyl compounds (amides, ketones, aldehydes, (carboxylic) alkanoic acids, carbohydrates (reducing and non-reducing sugars), alkylalane esters, and proteins (Anim- Eduful & Adu-Gyamfi, 2022).
c. Student learning: Students' attainment to specific standards includes skills that have to be acquired by the end of the unit, the standards are (HS-PS2-6, PS1.A, HS-ETS1-3).
d. Grade 12 students: Are the students between the ages of 16 and 18.

Chapter 2: Literature Review

2.1 Teaching and Learning Chemistry Globally and in the UAE

Due to its connection with other fields of science, such as Mathematics and Biology, Chemistry is regarded as a fundamental science subject (Abarro et al., 2021). However, chemistry is widely considered to be the most challenging subject in the world (Gafoor & Shilna, 2015). Chemistry is the toughest science subject to understand, and thus, fewer students are interested in it (Cardellini, 2012). Studying chemistry places enormous demands on both students and teachers. Regardless of chemistry's critical part and significance, the failure ratio remains exceptionally high worldwide (Hassan et al., 2017).

Several factors, including students' backgrounds, deficiency of interest, untrained teachers, and typical teaching methods with insufficient learning materials, may all contribute to students' poor achievement in Chemistry (Ogutu, 2020).Additionally, there are three levels of barriers: school, system levels, and teachers which may influence students' attitudes toward learning, possibilities for expert development for science teachers, schooling, andstudents' performance in chemistry (Surya & Arty, 2021).

Chemistry is taught as the main subject in tenth grade in the United Arab Emirates (UAE). Thinking mathematically is essential in chemistry learning, particularly given the nature of communal calculations in chemistry courses. Linking with TIMSS (Trends in International Mathematics and Science Study) exam began in 1995, the main goal of TIMSS is to evaluate the effectiveness of science and mathematics learning for students in grades 4 and 8 across participating countries. TIMSS also provides professionals in education with information and data that help them improve the educational achievements and outcomes of their students (Mullis et al., 2020).

Students in the TIMSS exam for grades 4 and 8 frequently need more core abilities to comprehend chemistry, which causes difficulty while studying organic chemistry and organic qualitative analysis in grade 12. Despite previous exposure to chemistry, these core skills are not fully mastered, limiting students' capacity to explore complex topics. As a result, students face difficulties appreciating the complexities of organic chemistry

and qualitative analysis, revealing a gap in their educational preparation that must be filled. According to the 2019 TIMSS results, students in the UAE have shown a steady improvement in their performance since the UAE's first participation in TIMSS in 2011. Specifically, at the grade 4 level, the averages of students' achievement in mathematics have been 434, 452, and 481, while for science, the averages have been 428, 451, and 473 in 2011, 2015, and 2019 respectively. At the grade 8 level, the averages of students' achievement in mathematics have been 456, 465, and 473, while for science, they have been 465, 477, and 473 in 2011, 2015, and 2019 respectively (Mullis et al., 2020).

It could be noticed that UAE students' scores are lower than the TIMSS international average of 500. Weak students' abilities in Mathematics during their early school ages could significantly impact their learning in various science subjects including Chemistry which could significantly impact their educational achievement in later grades. Such an impact could result in fewer career opportunities for UAE graduates in science, particularly Chemistry, because of students' decreasing interest in the subject (Akram et al., 2017).

In a study about the variables related to achievement in Chemistry and performance of students in the UAE, Khalaf (2000) reported that home environment, prior knowledge, academic ability, perceptions and attitudes related to science and Chemistry, and students' awareness of instructional practices are the factors correlated with achievement and performance of students in Chemistry. Various measures (i.e., school size, prior achievement of students, and students' opinions on teacher efficacy), have been implemented in UAE schools and classrooms to target students, teachers, and the whole learning and teaching environment.

Regardless of these measures, performance and attainment in Chemistry have deteriorated, with below averages noted year after year (Khalaf, 2000). The persistence of low achievement in Chemistry has been attributed to various factors, including students' attitudes toward chemistry, their level of motivation, learning resources, interpersonal relationships, collaboration, and class irregularity (Nja et al., 2019). Parental involvement is also essential in shaping educational aspirations and students' attitudes which is seen to have a significant effect on students' academic achievement in many cultures (Castro et

al., 2015; Jackson, 2022), parental expectations and aspirations for education of their children, connectivity with their child about school matters, parental influence, and parents' participation in school activities are all examples of parental involvement variables (Jeynes, 2007).

Parents' expectations and aspirations are the most significant critical features of parental involvement affecting the outcomes of school (Jackson, 2022). It is thought that parents link their hopes to their children and set academic objectives for them (Jeynes, 2007). Parents discuss the educational value with their children, discuss future occupational and educational expectations, and assist the child in making connections between real-world applications and schoolwork (Hill & Tyson, 2009). Many researchers have found that parents can convey the importance of Science based subjects to their children, which is linked to good academic performance (Sun et al., 2012).

Chu et al. (2015) emphasized the importance of teacher quality in improving students' achievement. When teachers have greater subject material understanding and knowledge, are focused on teaching, and teach higher quality material, students may have more opportunities to learn further (Hanushek & Rivkin, 2010). Hanushek (2011) discovered that when a high-quality teacher teaches a student, his or her academic achievement improves.

Many studies examined the relationship between individual students' attitudes and academic achievement characteristics toward learning (Erdogan et al., 2008). According to the research, students with negative attitudes toward learning exhibit problematic behavior (Ming, Ling, & Jaafar, 2011). It has been also discovered that living in slums and poor areas contributes to the low academic performance of students (Farooq, Chaundhry & Berhanu, 2011).

2.2 Studying Organic Chemistry

The study of carbon-containing compounds' structures, alignment, characteristics, and reactions is known as organic chemistry. Organic compounds also contain hydrogen, carbon, and numerous other components. Within sciences education, organic chemistry is an obligatory subject as it offers understanding of chemical phenomenon (Healy, 2019).

Science researchers admit students face challenges while grasping organic chemistry related theories and models such as organic reactions, synthesis of functional groups, chemical bonding, radical reactions, bond formations between conformational isomerism, carbon electrophiles and so forth (Graulich, 2015).

On three levels, chemical phenomenon has to be understood by the chemistry students that are as follow a) the association between atoms and molecules (submicroscopic & macroscopic) b) formulas and chemical equations (symbolic) and c) the association/relationship among submicroscopic, macroscopic and submicroscopic. Many educators only emphasize the representational components and macroscopic, while the microscopic components are sometimes overlooked and underutilized (Baah & Anthony-Krueger, 2012; Taskin & Bernholt, 2012).

As a result, students frequently struggle to understand and visualize microscopic concepts such as atoms, chemical reactions, or molecules (Akaygun et al., 2014). According to students, Organic Chemistry is a theoretical and difficult task with many theories to learn (Anim-Eduful & Adu-Gyamfi, 2022; Bhattacharyya & Bodner, 2005). Stieff (2007) adds that Organic Chemistry is thought to be difficult worldwide, resulting in students developing various misconceptions and poor comprehension. Therefore, students rely on memorizing formulas for organic compounds, which is not helpful for learning Organic Chemistry.

Therefore, to achieve an excellent consideration of organic reactions or analysis, students must fully intellectualize reaction mechanisms from one chemical reaction to the next until a stable product is made (Talanquer, 2018). These mechanisms are one of the numerous challenges that students of Organic Chemistry face. Problems are created when students attempt to categorize these organic compounds based on their knowledge of the various reactions, mechanisms, and physical properties (Hassan et al., 2004). Some studies, in contrast, have discovered that due to a lack of conceptual understanding, students cannot understand organic chemistry (Akkuzu & Uyulgan, 2016).

2.3 Organic Qualitative Analysis

Chemical analysis is an important part of learning chemistry. It can be broken down into two categories: qualitative analysis and quantitative analysis according to (Matthews, 2011). OQA is a systematic approach for identifying the components present in provided organic mixture or compound. Unlike the quantitative analysis, that focuses of determining the accurate quantities of substances, qualitative analysis revolves around ascertaining different types of functional groups within a sample. Techniques such as chemical tests, chromatography and spectroscopy are commonly practiced within OQA. identifying unknown substances is a key part of characterizing them.

Globally, chemistry students struggle to understand chemical reactions and concepts that underlie qualitative analysis. Moe (2011) states that misinterpretations and misapprehensions are most common when students experience new scientific theories. In grade 12, students in the United Arab Emirates study OQA as part of their chemistry curriculum. Functional groups are identified that are comprised or particular grouping of atoms/molecules that are instilled with unique chemical characteristics – functional groups include COO (esters), OH (aldehydes), $CONH_2$ (amides), and both aliphatic and aromatic hydrocarbons.

As per Buthelezi et al. (2020), further Aliphatic hydrocarbons are categorized in two divisions that are: a) alkynes and alkenes, unsaturated compounds, and b) alkanes, saturated compounds. Aromatic hydrocarbons are exemplified by benzene. To support students' knowledge of functional groups and avoid misunderstandings, basic concepts should be taught initially, which include the fundamental chemistry theories (Hanson, 2017). Researches prove that instructors who facilitate activity-based teachings and well-developed curriculum approach enable the students grasp scientific concepts effectively (Asghar et al., 2019).

According to Anim- Eduful and Adu-Gyamfi, (2021) the identification and characterization of unknown substance structures are crucial components of the organic chemistry curriculum in high school, particularly in grade 12. Scientists, chemistry researchers and chemists utilize this approach to differentiate the functional groups within unknown substances, which also explains regarding the chemical structure of elements.

For instance -OH (hydroxyl) comprises of alkanols (CnH_2n+1OH) which are classified in three categories: a) tertiary, b) secondary, and c) primary. During the oxidation phase, when oxidizing entities such as chromic acid reacts with primary alkanols, two atoms of hydrogen are lost.

The first oxidation reaction results in an alkanal (aldehyde), and the second oxidation reaction results in the formation of alkanoic acid. Because chromium's oxidation state changes from Cr6+ to Cr3+ in the presence of primary alkanols, potassium heptaoxodichromate (VI) ($K_2Cr_2O_7$) loses its orange color and turns green. The iodoform test is used to identify several alkanols. For yielding positive result, the alkanol must harbor an important key structure that is CH_3, methyl group is attached directly with carbon having hydroxyl (OH) group (yellow precipitate of iodoform CHI_3) – the arrangement allows the testing of tertiary, secondary and primary alkanols.

The primary alkanols such as ethanol and methanol, lack the alpha-methyl and therefore test negative. The secondary alkanols such as isopropanol with their alpha-methyl immediately undergo oxidation phase, corresponding to carbonyl if acetone is present followed by iodoform (trihaloformation) turning positive. The tertiary alkanols which lack alpha-hydrogen, fail to react are unable to be detected. Moreover, this test allows to differentiate ethanol from methanol, providing analytical insights.

Another functional group of alkanoic is the carboxyl group, also known as RCOOH, has the general molecular formula $C_nH_{2n}+1COOH$. A powerful oxidizing agent oxidizes primary alkanols to create many alkanoic acids. For example, potassium permanganate can be used to oxidize ethanol (CH_3CH_2OH) into acetic (ethanoic) acid (CH_3COOH). Within the esterification reaction, condensation of RCOOH (carboxylic acid) takes place with ROH (alkanol) under the catalysis of concentrated H_2SO_4 (Sulphur acid). The yield of the chemical reaction is alkyl alkanoate which is also known as the ester (RCOOR), with molecule of water (Zumdahl & Zumdahl, 2003).

Within organic chemistry, the identification of carbonyl compounds is critical such as ketones and aldehydes. Several tests are practiced such as: a) Brady’s Reagent (few drops of 2,4-dinitrophenylhydrazine react with the carbonyl groups resulting in orange or bright yellow precipitates), b) Tollen Test (aldehydes are transformed into silver mirrors

causing a reflective sheen on the test tube lining), c) Schiff's Test (adding carbonyl compound to reagent results forming oxide precipitate confirming its presence), and d) Esterification (when carboxylic acid is heated with concentrated sulfuric acid yielding alkyl alkanoate).

For the qualitative detection of amides, the amide solution with sodium hydroxide is heated, which produced the ammonia gas because of amide hydrolysis. The pungent odour and basic nature of ammonia facilitate its qualitative detection of the amide functional group as identified by (Morrison & Boyd, 1992). Moreover, regarding the multimodal learning within chemistry discipline, cognitive scientist Carey (2000) proposed concept formation via experience-based extrapolation. Students can build models actively to understand the connections and difference between several scientific concepts. Effective learning of chemistry subject involves the symbolic, sub-microscopic, and macroscopic representations. Hence, making connections between the levels promote learning (Sanger et al., 2000).

2.4 Factors Influencing Students Learning of OQA

2.4.1 Attitudes Towards Science

One of the factors that impact students' learning is their attitudes toward learning science. According to Astalini et al. (2020), students' attitudes have a direct link to students' achievement and may affect their performance. Hacieminoglu (2016) argues that students' attitude toward Chemistry is shaped by the way teachers teach it and might help them adopt an optimistic attitude toward science. However, most students in science classes seldom show positive interest in studying science (Ajemba et al., 2021).

Researches conducted at the turn of the millennium reported elevated levels of declining student achievement and engagement within science education. Student lacked proficiency within fundamental scientific concepts (Osborne et al., 2003). Students also displayed decreased enthusiasm and motivation towards science leading to negative attitudes. Studies also identified career disinterest as enrollment also declined. Further researches within Europe and USA attributed to these concerns to deficiencies in pedagogical strategies and curriculum content within the schools (Hofstein & Mamlok-

Naaman, 2011). Secondary school students also hold positive emotions towards science related subjects but overall have neutral attitudes (Montes et al., 2018).

As the students progressed academically from junior grade to senior their attitudes towards learning science related subjected deteriorated. The study conducted by Salta and Tzougraki (2004) found a significant association between student attitudes and performance in chemistry subject. The research investigated the factors of effort, and awareness of 12^{th} grade Greek chemistry students. The findings indicated of a neutral attitude however the students were unaware of significance of chemistry subject within common lives.

2.4.2 (Gender) Girls' and Boys' Attitudes

Seba et al. (2013) found a variation in girls' and boys' attitudes towards chemistry in regard to unease, pleasure, and self- confidence. Boys were more confident, performed well, and enjoyed Physics and chemistry than their female peers. Consequently, male students have more optimistic attitudes toward physics and chemistry than girls, and they are more likely than female students to participate in physics and chemistry activities. As per Jarrah (2020), the most common factors which positively impact the attitudes of students towards chemistry subject were found to be grade level, instructional methodologies and gender. Teaching methods influence students' attitudes towards science, which are crucial for learning. Negative attitudes, as noted by Hassan et al. (2017), might impede students' academic achievement.

Hassan et al. (2017) findings revealed that students' attitudes towards Chemistry significantly influenced the subject's performance. It was also discovered that students' attitudes toward chemistry impact their academic performance. This was discovered by examining the chemistry teachers' and students' attendance. According to the study, students with a negative attitude towards Chemistry performed poorer than those who had a positive attitude. Furthermore, research findings revealed that chemistry teachers played a significant role in developing students' negative attitudes toward chemistry. Specifically, teachers' teaching strategies affect what students accomplish in the classroom, their attitudes, and their overall performance. Thus, teachers play a prominent role in forming either negative or positive attitudes toward chemistry.

2.4.3 Language Capability

Researches such as Beka (2016), Alieto (2018) and Macro (2019) investigated the role of language within the domain of student's academic progress. This issue has been significant within Emirati context as teacher's majority population are foreigners hence, the English language proficient may differ from the UAE based students. That is, the student's level of language skills can significantly impact the student's science development and overall performance (Jarrah, 2020). Students' language difficulties in comprehending English instructional material correspond with the concept of language-rich learning environments as discussed by Cummins (1981). The students' inclination towards explanations in their mother tongue underscores the significance of acknowledging language diversity in teaching methods (García, 2009).

Foreign background students in university settings have 'language shocks' due to disparities in language systems, perceptions, and attitudes, as noted by Fan (2010). These shocks fluctuate in stages and strength, impacting emotions and learning. Students have linguistic challenges with aspects including tenses, plural nouns, pronunciation, articles, and prepositions that are not present or different in their home languages. Students face challenges in understanding various cultural subtleties in criticisms, feedback, praises, greetings, and titles from a sociolinguistic perspective. The problems are consistent with the studies carried out by James (1980) and Chesterman (1998), showing influences from their native languages. Discrepancies in language affect both the linguistic and socio-linguistic aspects of communication, impeding the student's understanding and assimilation into the academic environment.

2.4.4 Laboratory Techniques

Several studies have investigated the relationship between laboratory techniques, student achievement, and attitudes toward Chemistry. Practical experiments in the chemistry lab are essential for learning. In good chemistry education, what students learn in theory should be backed up by experiments (Kurbanoğlu & Akim, 2010). The goals of lab work include helping students understand scientific concepts, improve their problem-solving skills, learn how science works, and see the links between experiments and scientific theories.

According to Katsampoxaki-Hodgetts et al. (2015), when doing experiments, students should approach them like scientists. They need to identify problems, develop solutions, look for information, assess it, and discuss their findings with others. This process is known as scientific inquiry and helps students learn how to think and act like scientists. These studies found that laboratory activities can be more effective in helping students understand and apply science concepts. However, various challenges can hinder student learning in these environments, such as inadequate resources and equipment, ineffective teaching strategies, and students' attitudes toward education.

The studies also suggest that various approaches to teaching, such as inquiry-based or cooperative learning, can be more effective in promoting student learning and achievement than traditional lecture-based methods in these traditional labs, the focus is primarily on teaching scientific terms, concepts, and facts. Concannon and Brown (2008) mention that they provide very detailed procedures and tell students exactly what they should expect to see during the experiments.

In this method, students follow a step-by-step recipe from the lab manual, and the outcome is already known in advance. Students begin these experiments already knowing the scientific theory behind them. In this format, students are mainly concerned with just following the instructions in the lab manual. Consequently, they need the opportunity to develop higher-level thinking skills. Furthermore, verbal feedback and remedial instructions can help improve students' problem-solving skills.

2.5 Teacher Professional Development, Training & Development and Teacher Motivation

For several decades, within the educational paradigm, there has been a consistent debate regarding teacher quality being the most critical variable impacting the academic progression of students and achievement (Sancar et al., 2021). It was argued that dynamic shifts within educational landscape, along with the demand for elevated and improved pedagogical standards and high-quality education has escalated the expectations for teacher’s competencies and professionalism as well (Budd, 2004). Collinson et al (2009) also highlights that teachers themselves have also heightened their expectations driven byinnovative thinking within knowledge societies. This has led to educational leaders to

focus on how teaching quality can be optimized and consequently, the student learning outcomes. Hence, professional development programs become imperative to attain educational objectives (Sancar et al., 2021).

Boesdorfer (2019) argued that chemistry instructors/teachers across various educational levels guide students who pursue their careers as biologists, chemical engineers, chemists and other STEM experts while also fostering civil sense and participation. Improved inclusivity and instructional effectiveness positively correlated with increased student interest and achievement within chemistry subject. As per Driel and Jong (2015), the multifaceted nature of chemistry instruction makes it mandatory to comprehensively grasp the subject matter, student dynamics, pedagogical strategies and evaluative approaches. As educators facilitate the student understanding of Chemistry, they also require learning and training opportunities for their continual professional development to refine their instructional capabilities and widen content knowledge.

The training and development of Chemistry educators ensure updated knowledge and pedagogical competencies, enabling them to convey complicated chemical concepts effectively to the students (Dragisich et al., 2016). Furthermore, well-trained teachers adapt teaching methodologies for catering diversified learning styles, fostering a more engaging and inclusive classroom settings. Continual professional development equips teachers with the resources to integrated innovative teaching and modernized tech tools within lessons, improving the overall quality of the education. Educational institutions investing in training and development of chemistry teachers improves the overall standard of instruction, and cultivates a future generation of scientific literate individuals critical for societal and economic progress.

The research conducted by Guo et al. 2012 found teachers participated in the ongoing professional development forms, reported elevated motivational levels due to increased confidence in their instructional competencies. Furthermore, the research conducted by Arthars et al. (2019) confirmed that PD opportunities provided to teachers directly/positively correlated with greater job enthusiasm, and satisfaction leading to improved instructional quality and fosters engaged and motivated teaching workforce. Motivated teachers seek innovative teaching strategies/resources to fulfil the diverse needs

of their students hence improving the instruction effectiveness. Furthermore, they set high expectations for students and offer required support (Han & Yin, 2016).

2.6 Context and Structure of Chemistry Education in the UAE

Chemistry education in the UAE is evolving, blending traditional lecture-based methods with a growing emphasis on practical applications. Universities prioritize transferable skills alongside core knowledge. This can be contrasted with some Western systems where rote memorization might play a larger role in earlier years. However, some UAE schools are innovating. The American School of Dubai integrates project-based learning to foster critical thinking, similar to approaches used in progressive Western schools. A unique challenge in the UAE is the multilingual environment. While requiring more attention from teachers, it can be an advantage if addressed effectively. Students exposed to various scientific terms can be better prepared for the globalized scientific community. Overall, UAE chemistry education is moving towards a balance between strong foundational knowledge and modern pedagogical approaches, offering a unique blend compared to other educational systems.

2.7 Theoretical Framework

According to constructivism, students are active learners who construct their meanings based on prior knowledge they have gained through interactions with their environment. According to this theory, interactions, collaboration, observations, and engagements are the fundamental aspects of students' learning (Ziling, 2018). After this, students will begin to form their concepts about a specific topic and then apply it in real-life situations and other contexts.

Figure 1 depicts the constructivist approach to education, which holds that students are integral to learning and that new information is generated from real-world experiences. While things develop, everyone takes stock of their history and applies what they've learned. To organize their newly gained knowledge, students construct schemas. This was the guiding principle in the theories of learning put out by Bruner, Piaget, Dewey, Gagne, and Vygotsky.

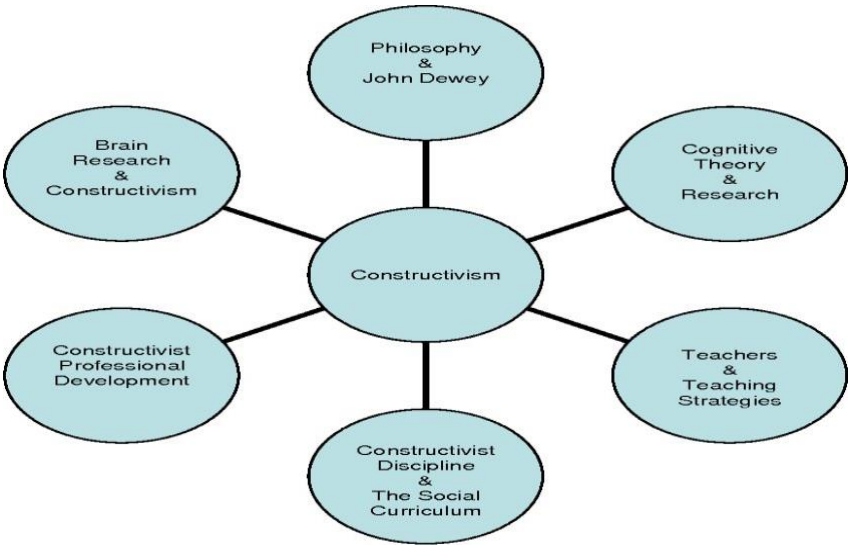

Figure 1: Constructivist Learning Theory.

One must be knowledgeable about constructivist theory to comprehend students' learning process. That students actively build their knowledge is the central premise of constructivism. Students build upon what they already know by drawing on their own experiences. Contrary to what Hoy and Woolfolk-Hoy (1993) said learning is not a passive process of absorbing information but rather an active mental effort.

The brain, the seat of learning, is constantly being unraveled by research, informing educational philosophies like constructivism. This theory, championed by John Dewey, emphasizes active knowledge building through experience. Constructivist professional development equips teachers with strategies to foster this – think project-based learning and social curriculums. These social curriculums tap into cognitive theory and research, acknowledging the social nature of learning. Teachers, armed with these strategies, become facilitators, guiding students to construct their own understanding of the world.

Teachers must have a firm grasp of constructivist pedagogy. Therefore, every student in their classroom brings a particular worldview shaped by their life experiences. The level of learning that children achieve will be impacted by this. Building new knowledge on top of what students already know is central to constructivist theory, which contends that kids learn best at the outset of their educational journey. Learning

theories are as important for teachers as qualifications; it is critical to understand what factors impact your students' learning.

Many different components make up constructivism. These fundamental ideas outline the concept and its effect on students' education. To gain information, students need to participate in class discussions and projects actively. Communicating with other people is crucial for gaining their understanding. Memorization is more effective when done in context. We learn by establishing connections between our prior knowledge and our beliefs, either in the framework of what we already know or as we go about our daily lives where learning happens.

Students can better organize concepts into categories and develop more insightful mental processes. Additionally, students realize that they are studying several concepts at once. Everyone participates in the learning exercise with their own set of experiences; therefore, they will all go away with distinct insights. The core principle of constructivist learning theory is that each individual's viewpoint and life experiences are fundamental. The theory of constructivism is applied in this study to make sense of how students learn OQA in chemistry.

This study uses constructivism, where students actively build knowledge, to understand how they learn Organic Qualitative Analysis (OQA) in chemistry. Beyond the hands-on lab experiences, teachers play a crucial role by facilitating discussions and encouraging students to connect OQA observations to existing knowledge of functional groups. The curriculum itself can also be designed with a constructivist approach, embedding activities that promote student inquiry and collaboration. By examining student attitudes towards OQA and how the curriculum and teacher guidance influence their learning process, this study can provide a more complete picture of how students construct their understanding of OQA in chemistry.

It has already been stated that constructivism stresses that students' heads cannot receive complete transmissions of information from their teachers' heads to theirs. Instead, students relate what they learn in class to their lives to make sense of it. Examining students' classroom experiences from the constructivist lens may provide teachers with a better understanding of how to select and use pedagogical practices to

establish a learning environment that is student-centered and activity-based focused.

Additionally, the constructivism theory may provide the researcher with a window to understand the experience of students by discovering their perceptions, challenges, and barriers. Specifically, the gathered qualitative data in this study, such as interviews and classroom observations will allow participants to describe or demonstrate their experiences or level of understanding as a result of constructivist practices.

Chapter 3: Research Methodology

The following chapter has discussed how the research was conducted. It also explained the methods utilized to inquire the research questions.

3.1 Research Paradigm

A research paradigm is like a set of standard rules and beliefs that scientists agree on when they do research. (Kuhn, 1963; Shah and Abdullah, 2013; Mingers & Brocklesby, 1997; Makombe, 2017). Before starting a research project, it's essential to figure out a few things:

a) What are you trying to find out about the world? (the ontological question.)
b) How can you learn about it and understand it? (the epistemological question.)
c) What methods and steps should you use to answer your questions? (the methodological question.)

These are all aspects of the research paradigm that are being investigated: how to do research? which technique to use? what to investigate? and how to study it? These are all components of the research paradigm. Furthermore, issues related to relevant methodological methods and instruments (Kuhn, 1963). Depending on the paradigm, different methods are utilized. For example, a positivist paradigm is about scientific research, using numbers and logic to describe facts and observations. On the other hand, an interpretive paradigm is eligible towards qualitative research, which tries to understand why something happened.

Within qualitative research, social phenomena are analyzed to understand why they occurred at the first place. Starting with specific details and building more significant ideas, concepts, hypotheses, and theories from them is the pathway. This approach often fits into the interpretive paradigm. Many research studies, especially doctoral ones, usually focus on scientific methods and concentrate less on qualitative approaches.

Some researchers like the idea of mixing both quantitative and qualitative methods instead of seeing them as opposites. They look for connections between these methods and

the benefits of using both. Research might hear about a "conceptual framework" more in qualitative studies and a "theoretical model" more in quantitative studies.

A qualitative research technique was employed to understand better the challenges faced by 12th-grade chemistry students in the UAE when learning OQA subjects. Since this study aims not to make broad conclusions but to identify specific problems with students' comprehension of the subject, a qualitative research technique is appropriate (Cresswell, 2009).

Three qualitative data collection instruments were used to acquire qualitative data from students regarding their knowledge of OQA: students' observations, which involved two chemistry teachers in their classes while teaching OQA during the second term for two weeks, so three classes per week for each chemistry teacher. I used an observation checklist, which was designed for this purpose. The purpose of this observation checklist is to find out from chemistry teachers and students whether the intended purposes of the lesson have been achieved. There are two sections (A and B). Section A seeks general information about teachers and students; Section B seeks expectations from teachers and students.

In addition, this checklist was established according to next-generation standard skills to cover the most essential skills in teaching OQA. Participants' interviews, which involved eight students from the 12th grade. Four different sections, three male sections, and one female section. The students were chosen randomly after I emailed the sections requesting their participants. I chose the first students who replied to me and showed interest. The information I obtained became saturated and repetitive, so eight responses were more than enough for my data. According to my case study, one female student was chosen because I found that her responses were different from her peers, Which gave me new insights that her peers did not mention, including student-teacher relationship, environmental factors, adaptation, Language barriers, Family involvement, and inspection.

Moreover, document analysis of teachers' and students like study journals, notebooks, and other relevant artifacts such as lesson plans, annual plans, and course

breakdowns. In addition, some documents from the lab technician assisted in my study. These documents included emails and other valuable documents related to the lab.

Further qualitative data analysis was done by thematic analysis to provide a basis for investigating the students' conceptual understanding of the subject. The output of the qualitative data is further discussed and informed by the relevant literature to understand better the factors that impact the learning of OQA in organic chemistry at senior high school level.

3.1.1 Purpose of Qualitative Methods

This study utilized qualitative methods, specifically semi-structured interviews, student checklist observations, and document analysis, to gain in-depth understanding of student experiences with OQA learning. Unlike achievement tests or existing scores, which measure outcomes, these methods allowed students to freely express their challenges and perspectives. Interviews provided rich details on student experiences, while checklists during observations captured specific learning activities. Document analysis of curriculum materials offered context for understanding the intended learning goals. This combination provided a holistic picture of how students interact with OQA, going beyond simple performance metrics.

3.2 Participants

Participants in this study are students enrolled in the 12^{th} grade in one of the international private schools in Al Ain city, UAE. The school hosts approximately 650 students and uses American Curriculum. There are four sections for grade 12^{th} students, three sections for male students, and one section for female students. Participating students were selected and consulted to be interviewed from each section. All interviews were held with participating students until the researcher reaches a data saturation level.

The rationale to select Grade 12^{th} students in an American curriculum school (UAE) was for their experience with OQA within this specific educational framework. The purpose of interviewing students was to obtain specifics and information that can be relied upon on the causes or elements that impact students' learning of OQA. During the interviews, it was ensured that the interviewer's perspectives and experiences do not sway

the opinions of the students because these conversations were recorded. Furthermore, questions were asked from students to make the interviews more interactive. The opinions of students regarding the process of teaching and learning OQA was used to produce themes.

To ensure a comprehensive understanding of student experiences, participants were selected from all four Grade 12 sections in the American curriculum school. This included students from both the single female section and the three male sections, promoting a balanced gender perspective. Inclusive criteria involved any student enrolled in Grade 12 chemistry. The only exclusion criterion was a student's unwillingness to participate. Interviews continued until data saturation was achieved, signifying a point where no new significant information emerged, ensuring a representative sample of student voices. This approach yielded participation from an unspecified number of students, allowing for a rich and diverse range of experiences to be captured.

The topics were provided to a few carefully selected experienced educators for their critiques and then subsequently for a peer review. The goal was to verify that students were genuinely engaged in OQA classes and to find out how much these learning activities impact their conceptual knowledge.

3.3 Ethical Considerations

It's essential to consider ethical issues at every study step. In this dissertation, I followed the rules and guidelines set by UAEU's Policy on Ethics. When collecting data, such as through interviews, it is essential to consider ethics. Participants willingly engaged, knowing they can withdraw from the study at any time. Before participation, it was ensured that the complete comprehension of the study's details and obtaining free, unpressured consent is crucial.

The approval from UAEU's Ethics Office was attained in November 2023 for semi-structured interviews. The names of the students, teachers, or schools in the interview discussion were not mentioned. The advisor and the committee of co-advisors looked at the interview questions and stated that they were suitable for answering the research

questions. They all agreed that the interview questions' material was relevant and helpful in addressing the study issues being examined (Willett, 2014).

3.4 Further Ethical Considerations Applicable to Interviews

When you do interviews, there are some essential ethical things to consider. First, you need to make sure that the people you're interviewing agree to be part of your study and know what they're getting into. You must also keep their information private and consider how your research might affect them.

It's crucial to be fair and not influence the answers in any way. When talking to people and gathering information directly, you must ensure you don't make them feel embarrassed, stressed, uncomfortable, or hurt. It would help to always look at things somewhat and unbiasedly. Again, in order to remain objective and unbiased, the researcher must never let themselves be embarrassed, stressed, uncomfortable, hurt, or harmed (Cowles, 1988). In order to remain objective and unbiased, the researcher must never let themselves be embarrassed, stressed, uncomfortable, hurt, or harmed (Cowles, 1988).

During the interviews, all the people being interviewed were told what the research was about correctly at the beginning. They were also given a printed copy of the questions they would be asked. The researcher got their verbal agreement to be in the study during the interviews, and they could change their minds any time if they wanted. Also, I informed the interviewee. The information collected during the interviews was kept safe on the researcher's computer with a password. The interviewed people were told their information would be deleted once the research was finished. So, the researcher followed all the rules for collecting data in a live setting.

In this dissertation, I also used data from checklist observations and looked at documents related to students and teachers. I spoke to chemistry teachers and lab technicians to understand their challenges when teaching this topic and course. All the information we gathered is kept confidential. Sometimes, the teachers and technicians shared reports about their work, students, or the school.

I also have information about the students' behavior, personal problems, academic performance, and how they get along with their teachers. I examined their exam results

and other things like annual reports related to students, teachers, and the school system. I will make sure to handle this information responsibly. ‘A code of conduct or expected societal norm of behavior’ is what Sekaran (2006) refers to when discussing research conduct. Ethical considerations in research refer to a set of rules or expected standards of behavior when doing research. These rules help guide how researchers should act. Another ethical concern involves the relationship between researchers and the people they study.

This is because the interaction between researchers and participants is crucial for uncovering hidden knowledge and understanding the real-life experiences of the participants. I want to know what those experiences mean to them. (Hesse-Biber & Johnson, 2015).

3.5 Selection of Interviews/ Participants

The present dissertation adopts a qualitative approach, analyzing interview data collected from individual participants. The study's primary objective is to gain a comprehensive understanding of the difficulties faced by UAE students in grade 12th when studying topics related to OQA in chemistry. Rather than seeking generalizations, the qualitative approach aims to uncover critical issues that impede students' comprehension of the subject (Cresswell, 2009).

Previous research has examined and measured factors influencing grade 12th students' understanding of OQA However, within the UAE context, this study is the first to identify the specific factors impacting students' comprehension in this area. The study's findings can be used to enhance students' understanding and may offer valuable insights for more effective delivery of chemistry lessons.

In selecting interviewees, the researcher employed purposeful sampling and probability sampling strategies guided by the literature. Purposeful sampling, or selective or subjective sampling, involves the researcher deciding which individuals from the target population to include in the study. On the other hand, probability sampling entails random selection of respondents.

For this study, interviewees were chosen based on specific characteristics relevant to the research objectives, ensuring they belonged to the appropriate group of respondents

qualified to participate. Therefore, the qualitative component of this research employed the purposeful sampling technique. While there is a substantial and expanding body of literature on qualitative research approaches, one area that requires further development is the estimation of sample sizes (Hagaman & Wutich, 2017).

Estimating sample sizes in probabilistic sampling is straightforward and can be calculated mathematically, even in qualitative research (Galvin, 2015). However, determining the appropriate sample size for purposeful sampling, commonly used in qualitative research, poses numerous challenges. Guest et al. (2006) emphasize the attainment of study-wide saturation, which means no new themes or findings emerge. Guidelines for determining sample sizes in non-probabilistic sampling are scarce. Purposive sampling is the most prevalent type of non-probabilistic sampling, and its size is often determined by reaching data saturation, where no new insights or themes are discovered (Guest et al., 2006).

Given the researcher's interest in obtaining in-depth information, purposive sampling is the most suitable technique for identifying high-quality interviewees. For instance, Cohen et al. (2013) conducted interviews with eight 12^{th} grade students, and their findings indicated data saturation regarding response quality.

3.6 Data Collection

To acquire qualitative data from students on their knowledge of OQA, semi-structured interviews, student checklist observation, and document analysis of the existing information was used for data collection. Participants' interviews considered as the main data source in this study. The observation checklist contained a set of items to assist the observer in evaluating students' understanding and behaviors (to what extent they are able to understand the concept of organic chemistry). The student observation checklist designed by the researcher with the help of two chemistry teachers. Depending on the core standards of the unit identified by the used NGSS science curriculum. Those standards include skills that need to be acquired by the end of teaching the unit, standards are (HS-PS2-6, PS1.A, HS-ETS1-3) according to these standers (HS-PS2-6, PS1.A, HS-ETS1-3). "HS-PS2-6", "PS1.A", and "HS-ETS1-3" are Next Generation Science

Standards (NGSS) identities. Each identifier corresponds to a distinct performance expectation or disciplinary core principle in the NGSS. To describe each of them in depth

HS-PS2-6: Communicate scientific and technical information about why the molecular-level structure is essential in the functioning of designed materials, so it is. Explain the significance of molecular structure in material function. This high school Physical Science (PS) performance goal focuses on comprehending molecular-level structures in created materials. The learning outcomes of this standard are significant, as students are expected to present scientific and technical knowledge regarding why understanding molecular-level structure is critical for the proper operation of materials intended for specific applications. This could involve knowing how the arrangement of atoms and molecules influences the properties and behaviors of materials in various applications, thereby shaping their understanding and skills in this field.

PS1.A: Structure and Properties of Matter.

PS1.A is one of the discipline's basic ideas in the NGSS architecture. It focuses on the fundamentals of matter's structure and properties. Students must learn about the composition of matter at the atomic and molecular levels and how the organization and interactions of atoms and molecules influence material qualities. This fundamental concept is the foundation for comprehending various chemistry and materials science phenomena.

HS-ETS1-3: Evaluate a solution to a complex real-world problem based on prioritized criteria and tradeoffs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impact so This performance objective applies to high school engineering and technology (ETS). It emphasizes the capacity to assess potential solutions to difficult real-world issues. This is about finding the correct answer and developing critical thinking and decision-making skills. Students are expected to study and evaluate viable solutions using a set of prioritized criteria and tradeoffs. This review process should consider various restrictions, including cost, safety, dependability, aesthetics, and potential social, cultural, and environmental

consequences. This activity enhances students' critical thinking and decision-making skills, which are crucial for tackling engineering and technological difficulties, empowering them in their learning journey.in summary, These descriptions provide an overview of the expectations and concepts of each standard within the NGSS framework.

The decision to use the Next Generation Scientific Standards (NGSS) as the basis for creating the observation checklist originates from it comprehensive and research-based approach to scientific education reform. The NGSS standards are a forward-thinking framework that integrates scientific procedures, crosscutting concepts, and disciplinary core ideas, resulting in a more cohesive and student-centered approach to science education (NGSS Lead States, 2013). By connecting the observation checklist with the NGSS standards, researchers ensure that student behavior and thinking observations are based on a solid framework that promotes critical thinking abilities, scientific inquiry, and conceptual understanding.

Moreover, the alignment of the observation checklist with the NGSS standards fosters consistency and coherence in evaluating student behavior and thinking across diverse educational settings. The NGSS standards establish a unified language and set of objectives for science education, facilitating collaboration among educators, researchers, and policymakers (NGSS Lead States, 2013). By basing the observation checklist on the NGSS standards, researchers can effectively evaluate how instructional practices foster the development of key science competencies outlined in the standards. This, in turn, contributes to advancing science education reform efforts and enhancing student outcomes (NGSS Lead States, 2013).

Using this checklist, students were observed while learning the topic. It is worth noting that items in the observation checklist were aligned with ideas from reviewing related literature and previous studies. Additionally, the observation checklist used as a formative assessment tool to collect data on specific classroom behaviors and students' thinking (brainstorming to solve a chemistry related problem).

In the semi-structured interviews, participants were asked to express their views and feelings in-depth. The interview questions will be prepared ahead of time and will be

open-ended in nature. Specifically, the interviews had a set of major questions to be asked to grade 12th students to explore factors affecting their understanding of OQA. Based on their answers, additional questions may be asked during the interview session for further elaboration.

Considering the document analysis, artifacts related to students' teaching and learning were collected and analyzed. The collected documents included teachers' lesson plans, annual plans, course breakdowns, classroom worksheets, PowerPoint presentations, and students' notebooks and assignments. The information tabulated in NVivo12 software form to analyze the collected documents from these various sources to sort and categorize them into different themes. Document analysis is a systematic procedure that is implemented to elicit and develop a further understanding of possible factors that influence students' learning of OQA.

The credibility of the qualitative research goes in-depth into a four-part series, in which trustworthiness is maintained. These four aspects of trustworthiness are transferability, confirmability, dependability, and credibility. For the first aspect, credibility was maintained by linking the research findings with reality so that truth can be demonstrated through the study's findings. Transferability is the degree to which qualitative research's findings can be transferred or generalized to other settings or contexts. In this study, transferability was maintained by using the member checking technique to ensure that the meaning the researcher reached reflects exactly that of the participant.

For dependability, several techniques were used in this research, in which the best way to build dependability is an inquiry audit (outside researcher conduct). This technique is also referred to as an external audit. In this research, the researcher analyzed the processes of data analysis, data collection, and the research study's results. This step was considered to ensure the accuracy of the results and, more importantly, the results from the collected data.

This type of analysis (inquiry audit) was beneficial because it allowed a researcher to step back and question how data analysis and interpretation occurred. Furthermore,

using this analysis, the researcher constructed meaningful themes and confidently align them with participants' narratives based on valuable insight from the inquiry audit.

The inquiry's transferability means how well its findings can apply to other situations. Qualitative research mainly concerns moving insights from one case to another (Tobin & Begley, 2004). Figuring out which places might want to use the results is still a question for the researcher. However, researchers need to explain things thoroughly to know if the findings could work elsewhere (Lincoln & Guba, 1985).

Researchers usually include thorough explanations of their study's setting, participants, data-gathering procedures, and results in qualitative research to keep it transferable. In this way, people may determine if the study's conclusions apply to their situations. Here are some common ways I used them as a researcher to enhance transferability:

Detailed Descriptions: I described the research settings, participants, and processes. Comprehensive descriptions allowed the readers to understand the context and circumstances under which my study was conducted.

I ensured that my study comprehensively described the research context, including the educational settings in UAE high schools, the characteristics of the students, the curriculum, and the specific challenges related to learning OQA. The more detailed and precise descriptions, the better potential users can be judged for the transferability of my findings to their contexts. So, I made sure to give detailed explanations about where and who I studied and the steps I followed. This way, people who read my study can understand the situations and conditions in which my research was done.

To maintain transferability in my research, I provided much information about where I conducted my study, the students I worked with, the school curriculum, and the specific issues the students faced when learning OQA. The more detailed and precise my descriptions are, the easier it is for others to decide if my findings can be helpful in their situations.

I. Participant Profiles: In my study, I gave many details about the participants. This included the things like how old they are, what grade they're in at school, what they

already know about chemistry and any other important information about them. Doing this will help readers understand who the study's findings might be helpful for.

II. Data Collection and Analysis Methods: In my research, I provided a concise and thorough account of the steps taken to collect and analyze the data. This encompassed explaining approaches, for example, interviews, observation, document interpretation, or thematic analysis. This aspect of the paper required the researcher to be transparent about how the data was collected, the tools or instruments used and the process involved in data analysis and examination. Such transparency allowed others to scrutinize my methods and provide value for their research.

III. Reflexivity: In my work, I was clear at the outset that my personal views might have got in the way of the fairness of the research process and the accuracy of the results. Thus, it would help if researchers are honest with their perspective imparted to the interpretation since it could also be the dominant factor.

IV. Member Checking: If you have considered the views of the people you learned from to achieve credibility, remember to include that. This can make the research more believable and useful to others. Sometimes, as a researcher, I asked the participants to check if what I found matches what the participants think. It's like a double-check to make sure the results make sense to the people involved

V. Triangulation: To strengthen the research, I used different ways to collect information and checked my findings. This made the present study more reliable and increased the chances that what I discovered could be helpful in various situations.

VI. Contextualization: I discussed regarding the bigger picture of education in the UAE in my research. This meant I explained the school system, what students learned, and anything unique about how education worked there. Doing this help others understand how my research findings might or might not apply to similar situations.

Researchers must show how they arrived at their conclusions and interpretations to prove that their results and interpretations are based on the data (Tobin & Begley, 2004). This is because confirmability is all about drawing inferences from the facts. Credibility, transferability, and reliability are the three goals of confirmability, according to Guba & Lincoln (1989). To help people comprehend the reasoning behind researchers' theoretical, methodological, and analytical choices, Koch (2006) recommended including indicators like these throughout the study.

To establish the validity of qualitative data, it is necessary to review it many times during processing and gathering to ensure the results can be reproduced. One way to describe this is via a coding system that clearly outlines the codes and patterns discovered during the investigation. To put it simply, it is the process of checking if your study's results are credible and unaffected by bias, I can explain the steps I took to maintain this in my research. This includes using clear methods, keeping records or notes, and involving others like my adviser and friends to review my work and conclusions.

In the study titled "Factors Influencing UAE High School Chemistry Students' Learning of OQA: A Qualitative Study", confirmability was prioritized to ensure the reliability of the research. The results were deemed confirmable as they were derived solely from the data and analysis, devoid of preconceived assumptions or biases. Several strategies were employed to maintain confirmability:

Transparent Data Collection**:** The data collection process was meticulously described. Interviews with grade 12th students, checklist observations, and document analyses were conducted, providing a comprehensive understanding of the questions asked and their administration. Classroom activities were observed, and observation methods were clarified, ensuring that peers could fully comprehend and replicate the data collection process, thus instilling confidence in the reliability of the research.

Data Coding and Analysis**:** The process of analyzing the collected data using NVIVO12 software was shared. Codes, categories, or themes used to interpret the data were described, and how these codes and categories were derived was explained. This demonstrated transparency in the analytical process, ensuring that the interpretations were grounded in the data.

Coding Consistency**:** To maintain confirmability, another researcher or colleague independently reviewed and coded a portion of the data. Consistent conclusions reached by both the independent coder and the researcher added validation to the findings, demonstrating that personal perspective did not solely influence interpretations.

Maintaining an Audit Trail**:** A clear record of the research process was kept, including notes, audio recordings, pictures, transcripts of interviews, and descriptions of coding decisions. This audit trail allowed others to trace the steps taken and verify the trustworthiness of the analysis.

Peer Review**:** The collaborative nature of the research was emphasized through discussions and peer review sessions with other researchers or experts in the field. This provided valuable feedback, offered different perspectives, and reduced the influence of personal bias on the findings, enhancing the credibility of the research.

The study demonstrated confirmability by including excerpts from interviews or observations to show how conclusions were reached. Steps taken to address potential researcher bias or subjectivity were also explained, ensuring that the findings were rooted in the collected data and not influenced by personal opinions, thus making the research more credible and reliable.

3.7 Data Analysis

After the completion of the data collection stage, all data gathered using participants' interviews, observations, documents analysis were analyzed using content analysis, narrative analysis, discourse analysis, and conversation analysis (Bowen, 2009). On one hand, content analysis focused on the content itself (what was said), conversation analysis focused on the form of the text (how something was said), and narrative analysis and discourse analysis both focused on both the form and the content. Thus, the qualitative data were analyzed using thematic analysis to extract the responses and organize them into recurring themes and patterns.

3.7.1 Data Analysis Software (NVIVO12)

This study emphasized the significance of qualitative research in exploring data thoroughly, testing and generating theories, and addressing gaps identified in quantitative research. NVIVO12 served as a pillar for qualitative data documentation, requiring precise attention to every aspect. More importantly, the study had essentially provided impetus for understanding the communication gaps that students encountered in relation to their qualitative analysis studies for 12th graders in UAE, particularly in terms of how to enhance their chemistry performance.

Utilizing the powerful application NVIVO12, researchers were able to process and draw deeper insights from the qualitative information collected. It simplified many tasks previously done manually, including sorting, processing, and analysing information, making the entire research process faster and more accurate. Specifically, NVIVO12 excelled in the following areas:

I. Data Management: NVIVO12 presented an option for integrating various data types from diverse online sources, such as video, audio content, documents, social media, and other websites. This facilitated the app's function by committing all data to a single location for convenient access. Researchers also had the capability to make queries and searches across their data, identifying patterns and relationships that might be difficult to see otherwise. This feature helped to obtain new information and establish connections within the data.

II. Visualizations: The NVIVO12 software helped researchers translate their research results into visuals like graphs and charts, creating an informative and appealing presentation. This explained why getting others to understand the findings or communicate effectively was essential.

III. Collaboration: NVIVO12 functioned as a tool that effectively encouraged collaboration between researchers through its data sharing and results exchange mechanism. This was a team effort that benefitted the whole research process through shared opinions and feedback.

In this study, NVIVO12 facilitated a thorough data analysis by helping to pinpoint key themes, compare respondents' perspectives, and connect the findings with established literature while using applied theories. Three steps towards software that could aid and support qualitative data collection through interviews, one of the most common research methods in field research and ethnography (Palinkas et al., 2015).

Computer-Assisted Qualitative Data Analysis Software (CAQDAS**)** packages, such as NIVO, MAXQDA, and Atlas, revolutionized the way qualitative data was analyzed, replacing the previous need for manual procedures. This software is often used in disciplines like humanities and marketing to help understand people's behavior and experiences.

As part of the study, NVIVO12 was chosen as the CAQDAS tool. The researcher taught the tool in their online classes. For proper learning of NVIVO12, the researcher attended an additional training session on YouTube. With NVIVO12, researchers were able to thoroughly interrogate the data thanks to the search and coding tools. The entire set of transcribed interviews was sourced and placed directly in NVIVO12. The software's searching tools allowed for both manual and automatic coding to be completed, with each node representing a specific theme, place, person, or area of significance.

Nodes functioned as neighboring storage areas (tree nodes or node matrices) for themes and subthemes, aiding analysis and providing an audit trail for participant trust in the research process. The topic of NVIVO12 included word frequency (WF) as a significant part of the study. WF specified the frequency of a particular stimulus rather than a word or event appearing in the text, as described in the introductory section to NVIVO12. Modulating the frequency (WF) of the stimulation besides the outcome ensured accuracy and consistency in the results, allowing researchers to better deduce how the stimulus affected the outcome.

Using WF queries facilitated finding the most used words or ideas in the files, especially in the early stages of the project. Researchers could also query all words that most characterized a group by introducing queries, terms used in coding nodes coded as 'case'. The code developed due to the WF could then be the systematic query basis (Figure

2). In the beginning stages of this project, the WF query helped identify the top 50 words in student interviews to find the node.

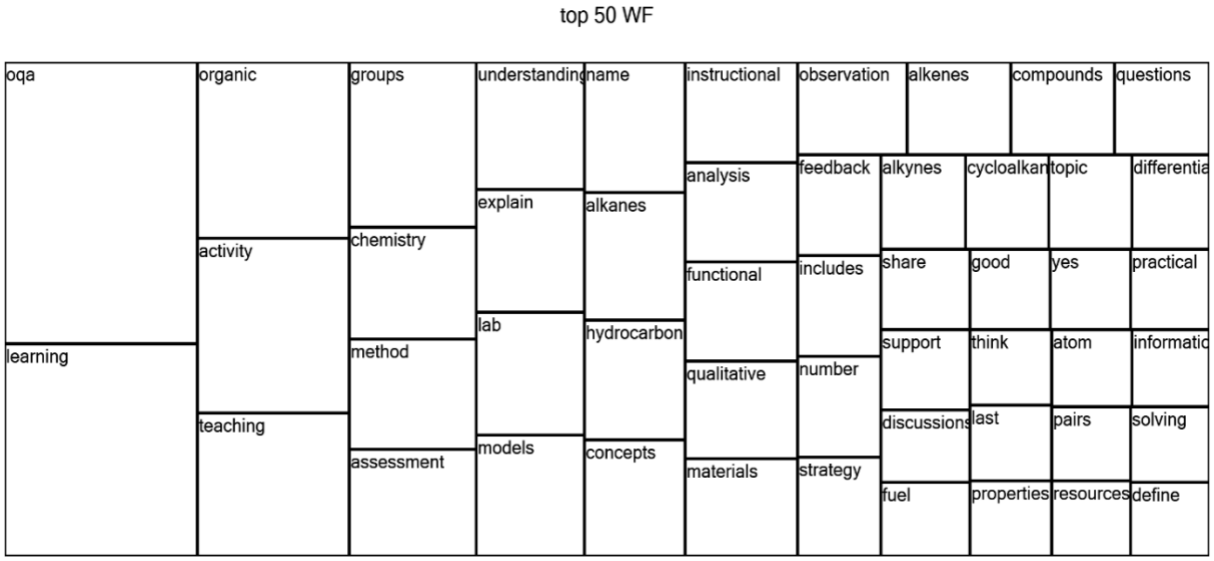

Figure 2: Word Frequency (WF) And Map (50 Top Words in Student Interviews).

The results demonstrated that nodes were automatically gathered, renamed, and combined into a hierarchical structure. This structure facilitated in-depth analytical coding according to the study objectives. The final structure and scaffolding of the nodes' hierarchical layout were produced. (Figure 3) below shows the fifteen nodes that comprised the final qualitative analysis node structure.

Figure 3: Theme and Sub Theme Node (Hierarchy Chart).

NVIVO12 played a vital role in strengthening the validity of the findings. It achieved this by enabling a rigorous examination of the data. Qualitative research demands meticulous exploration of selected inquiries to ensure thorough data analysis. By utilizing NVIVO12, the researcher was able to identify and delve into critical aspects of the study, ultimately resulting in a comprehensive analysis.

Chapter 4: Results

In this qualitative study, various methods were employed to gather data, including interviews with 8 students in grade 12th, lesson observations were carried out with two chemistry teachers to further examine the teachers' teaching practices related to teaching OQA lessons. Grade 12th students in an American curriculum school (UAE) were chosen for their experience with OQA within this specific educational framework. This research project also included document analysis, which involved looking at a variety of written and recorded sources, including texts, reports, articles, correspondence (such as letters and emails), legal documents, and any other pertinent materials that could provide insightful information to deepen the researcher's comprehension of the topic.

As I mentioned, the study focused on eight students who shared their experiences, both positive and negative, as they transitioned into an American school in the UAE. During the interviews, the researcher asked every participant to share a comprehensive overview of their background, including details about their upbringing, full name, academic class, hobbies, nationality, and high school experiences related to learning OQA. The researcher subsequently utilized these various pieces of information to address the 3 questions, where she selected one out of the eight students for an in-depth case study.

To ensure the reliability of the findings, the study incorporated triangulation of data by reviewing student work and documents shared between teachers and students. A more comprehensive understanding was achieved by comparing the information provided by the students with the data obtained through lesson observations and student-teacher documents within the school.

It is crucial to understand that the research did not differentiate between male and female students enrolled in OQA. The research treated all students as a single group. It did not analyze experiences, responses, or outcomes based on gender and instead treated all students as a cohort, highlighting the lack of gender consideration in the research design. To maintain confidentiality, pseudonyms were assigned to the students. This study's main objective was to investigate the factors that affect UAE grade 12th students' understanding of OQA subject in chemistry.

The goal was to determine the barriers to students' understanding as well as their perceptions of OQA. The researcher gained natural insights into the student's experiences, academic achievements, and failures through individual-focused interviews. The data collected from each participant was individually analyzed, leading to the emergence of overarching themes encompassing all participants' experiences.

4.1 Interviewer's Knowledge and Credibility

In qualitative research, the knowledge and credibility of the researcher play a crucial role (Patnaik, 2013). This is particularly true when conducting interviews, as the interviewer must possess technical expertise and strong interpersonal skills. In the context of this dissertation, the researcher holds the administration position, and she acts as a head of the department in school setting. She has been working at the same school for over eight years. Furthermore, the researcher boasts more than 13 years of experience in teaching and learning, gained from working in the UAE and the US. These extensive experiences enhanced the researcher's credibility in the eyes of the interviewees (Patnaik, 2013).

Moreover, the researcher's familiarity with the school, its students, teachers, and staff further strengthen her position. Being a part of and working at the same school, the researcher has developed a deep understanding of the dynamics within the institution. As the head of the department, she regularly conducts observational visits and uses checklists to assess the performance of the two chemistry teachers. This established rapport and familiarity for the researcher to collect data and information. The teachers felt comfortable and are more willing to assist in providing the required documents and information.

Additionally, the researcher's familiarity with the laboratory materials, chemicals, and processes, along with the support of the lab technician, allows her to access the necessary information and even obtain pictures of the lab setup. Being the head of the science department enables her to keep an open line of communication with the teachers. That helped to create a relaxed environment where teachers can openly share their truthful information. Similarly, students felt at ease during the interviews, making the data collection process more effective and reliable.

After conducting interviews with students, I gathered additional information from two teachers who were approached as colleagues and friends rather than using a formal interview format. These two chemistry teachers shared additional details concerning the inadequacy of materials and chemicals within the laboratory, the unsuitability of the lab space for accommodating a large number of students, the presence of expired chemicals, and the insufficient budget available to teachers for procuring materials.

Furthermore, they pointed out the prevalent low academic proficiency levels in chemistry and English among most students. The interviews with students were transcribed, and the data was then analyzed using NVIVO12 to identify patterns and themes. Thematic analysis was then used to answer the following three research questions.

I. What factors influence 12th grade UAE students' understanding of OQA?
II. What are the challenges that 12th grades students face in conceptualizing OQA and how to overcome these challenges?
III. What sort of support do 12th grade students need to better understand OQA?

The purpose of this qualitative study was to examine the variables impacting the comprehension of OQA among 12th graders in the United Arab Emirates, and the three research questions aimed to determine what accounts for the difficulties that students in high school have when learning and teaching OQA. The research sought to identify students' challenges in comprehending this topic and explore potential strategies to overcome these obstacles. Additionally, the study aims to determine the support and resources that 12th grade students require to enhance their understanding of OQA.

By addressing these questions, the research aimed to provide valuable insights into improving students' educational experience and academic success in this subject area. To achieve this, I observed two chemistry teachers using an observation checklist in their chemistry classes during the second semester while teaching the OQA; the observation lasted for about two weeks in each week 3 chemistry classes for each section (three Boys section and one girls’ section).

Regarding the first research question, which focused on studying chemistry and practical skills for teaching OQA, emergent themes included resources for teaching and learning, relationship with chemistry teachers, and using modelling in learning OQA. The

second research question pertained to laboratory practices and instruction based on practical learning. Emerging themes included going to the lab every week, using modelling in teaching OQA, having materials in the lab, and providing examples for experiment in lab. And the third research question focuses on the support and help that grade 12th have to understand the topic.

Finally, the researcher identified themes (Figure 4 a & b) that were relevant to all three research questions such as understanding organic compounds and explaining concepts related to OQA, difficulties in learning OQA, expectations for learning OQA, the meaning of OQA and the field of OQA as content for the organic chemistry curriculum.

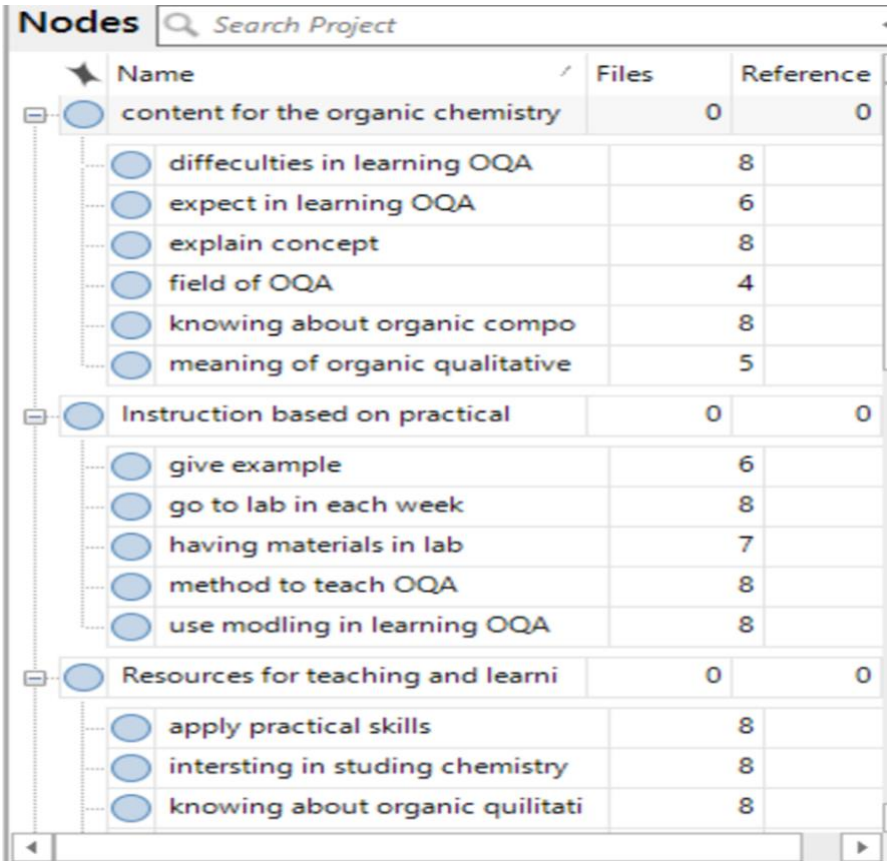

Figure 4: Themes and subthemes. (a) with Node (b) without node

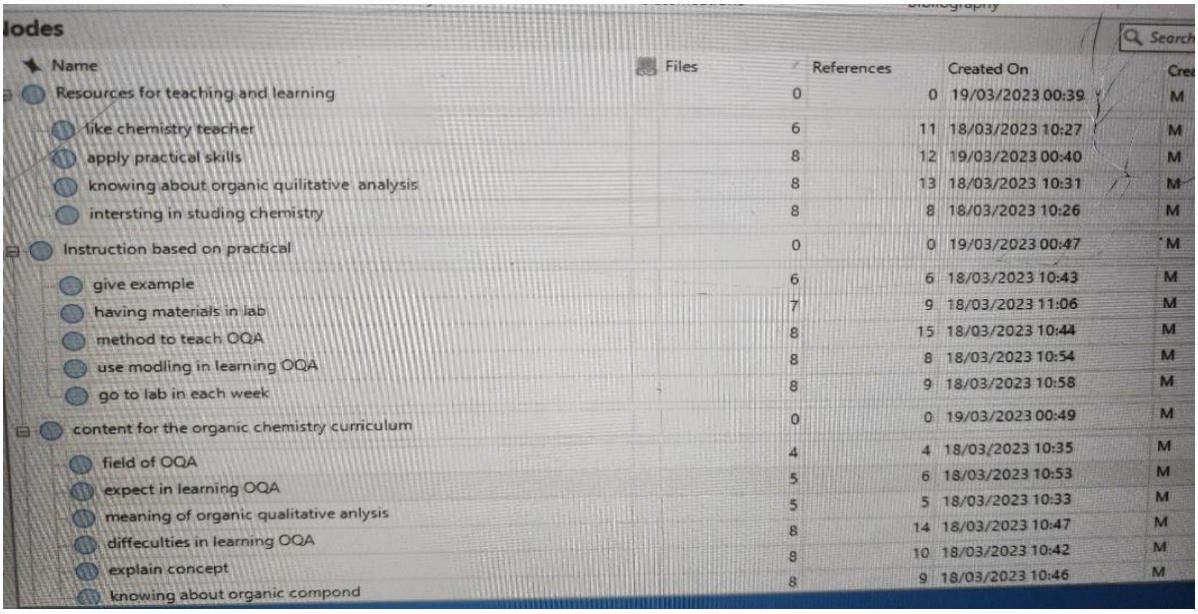

Figure 4: Themes and subthemes. (a) with Node (b) without node (Continued)

Three major themes emerged from analyzing the data collected through interviews (Figure 5) observations, and documents:

I. Teaching and Learning Resources: This theme centres on providing enough resources to teach practical-based OQA training effectively. These include labs, reagents, and equipment that are necessary for the learning processes to go on.

II. Practical-Based Instruction: This theme addresses teachers' methodology for instruction, focusing on the participatory-based scenario to promote students' understanding of chemical concepts. It investigates how teachers' hands-on' approach, such as through practical discussions, makes the students understand the OQA better.

III. Organic Chemistry Curriculum Content: This area is dedicated to the analysis of teachers' and students' perceptions of OQA class content within the framework of the official curriculum. This study about the learners' understanding of the link between curriculum design and methods used in OQA lessons is being coached.

Name	Files	Referen
content for the organic chemi	0	0
Instruction based on practical	0	0
Resources for teaching and le	0	0
students background	8	8

Figure 5: Three Main Themes that Emerged from Interviews.

Results of Question 1: What factors influence 12th grade UAE students' understanding of OQA?

This question aimed to investigate the factors contributing to challenges teachers and students face in teaching and learning Organic Chemistry Laboratory Activities (OQA). This investigation involved observing two chemistry teachers to gain insights into their methods of delivering OQA lessons. Additionally, interviews were conducted with both teachers and students before and after these lessons. In the following paragraphs, I will present the various factors that grade 12th students encounter while learning OQA.

4.2 Students' Familiarity with OQA

The interviews and lesson observations revealed a significant challenge teachers and students faced in teaching and learning OQA. One major issue was that not all students were familiar with the term "OQA, which is "a method used to determine the number of elements or molecules produced during a reaction". This lack of familiarity was due to a need for more resources. Both teachers and students needed more tools and equipment, especially in the laboratory such as; test tubes, heating devices, and chemical materials (Br_2/CCl_4, $NH_3/AgNO_3$, $K_2Cr_2O_7$, Benedict's solution, and Fehling's solution) that are essential for conducting chemical experiments.

To understand the student's background and familiarity with organic chemistry and OQA, the researcher asked some students about their prior knowledge of OQA. Some of them mentioned that they had been introduced to organic chemistry and OQA and were familiar with these topics. In contrast, others were confused about it and described it as a fascinating *topic*. Here are a few quotes from the interviews.

Interviewer: Are you familiar with organic chemistry and OQA?

Ahmad: "I believe so, but it looks confusing, making me reluctant to learn it. Do you mean hydrocarbons? If Yes, Then, of course, I am familiar with OQA (class A, Student 1).

However, Zaid mentioned that the whole topic of hydrocarbons is complicated to him:

Zaid: Do you mean our lesson about hydrocarbons? Yes, Miss, it's complicated to understand (class C, Student 2).

Majed: No, eeeh, yes, Miss. It does not detect functional groups like alkenes, alkanes, & .... alkanols.

Interviewer: Yes, close; we call those hydrocarbons in organic chemistry. Can you explain OQA in your own words?

Majed: Oh, I see. I'm not sure because chemistry isn't my best subject, but I guess it's related to understanding functional groups using lab experiments. " There has been no lab work or practical application, but yes, we have done them. Since I am confused by them, I have not been studying them regularly." (class A, Student 2).

*Rawa**:** Yes, in fact, yes. I know what that is; studying hydrocarbons is a fascinating topic for me. I like learning them, but I have difficulties handling it, but it is enjoyable. (class D, Student 2)*

Same ideas were echoed during my observations of tow chemistry lessons in grade 12^{th} classes. I noticed that chemistry teachers talked about the OQA topic and tried to reintroduce to their students several times throughout my visits. However, students still requested some practical and hands-on activities to help them better understand the concept. The teacher responded to his students requests and mentioned that he will take them to the lab to do some chemical activities including the reactions of organic reagents with functional groups:

"We will conduct these experiments in a controlled environment so that you can see and feel the interactions between the organic reagents and the functional groups" (Mahmoud, a teacher)

Another teacher also mentioned that he would try to conduct practical work in the lab if his students finished the functional group detections. He said during the observation:

"Once we finish these functional group detection tests, I will try my best if we can do actual practical work in lab (Tareq, teacher).

4.3 Limited Lab Space and Big Class Size

The space of the lab and the large number around 35 of grades 12^{th} students in the schools were identified as factors that contribute to the challenges they face while teaching OQA to students. They complained that the school did not have enough space that is designated solely for chemistry laboratory use. When one of the students asked why they don't go to the lab to do experiments, the teacher replied:

"... since we don't have enough space in the lab and our number is large, we can't go to the lab; therefore, we are going to stay in the classroom. Maybe next time, my dear students, we have a lot to cover" (Teacher Tareq Class Observation).

When I asked the teacher why he couldn't, he added: *"Not only does our school lack laboratory space, but also basic chemicals and reagents are not available in chemistry lab".*

The lab technician also mentioned that the concern of limited lab resources and equipment is a problem that limits them from taking their students to the lab. They both mentioned that the only organic material that we have in the laboratory in this entire school is ethanol. Even that ethanol has been there for more than a year. They mentioned:

"*Most of the remaining compounds are inorganic salts and solutions, to be very honest. Those chemicals are really pricey, and my pay isn't nearly enough to cover their cost for the school. I'm stuck. $K_2Cr_2O_7$, Fehling's and Benedict's solutions, and Tollen's reagent are not available at the moment, thus we cannot do tests for higher functional groups such as alkanols, alkanoic acids, aldehydes, and ketones. On the other hand, we may check for unsaturation and saturation functional groups using reagents like $KMnO_4$ and bromine solution. (Lab technicians)*

Significant challenges are evident which the teachers face in delivering Organic Qualitative Analysis (OQA) labs due to a lack of resources. Teacher overcrowding and insufficient lab space prevent students from gaining crucial practical experience. Compounding the issue is the absence of essential chemicals and reagents, including those needed for identifying key functional groups like aldehydes, ketones, and carboxylic acids. The lab technician acknowledges the high cost of these materials but feels powerless to address the situation. This lack of resources forces teachers to rely on demonstrations or forego OQA lessons altogether, hindering students' ability to grasp the practical aspects of organic chemistry.

4.4 Outdated Chemicals and Reagents

Sometimes, while teaching OQA to students, old chemicals and reagents (Figure 6) are used. This was found not to provide students with the best OQA experience. One teacher mentioned;

"Even the few chemicals we use for the inorganic practical works are outdated; some have been outdated for four and even five years. As the only chemistry teacher for the three streams, this makes it particularly challenging for me to conduct practical classes." (Mahmoud, a Teacher).

	Name of the material	Expired date	Catalog code
1	Hydro chloric acid	2018	Not available as it is old
2	Nitric acid	2018	SLN2161
3	Sulphuric acid	2018	Not available as it is old
4	Ammonia	2018	Not available as it is old

Figure 6: Chemistry Lab Expired Material Report Materials That Are Expired in Our Chemistry Lab.

Additionally, students who were interviewed agreed with their teacher's assessment that their school lacks sufficient chemicals and reagents for teaching OQA, which sometimes limits their understanding of various aspects of OQA. Here is one of the students' responses:

"We are constantly shown examples of chemicals on the whiteboard (Figure 7) or some pictures on PowerPoint slides that these reagents are used to detect organic functional groups, and we get confused since we have never seen these reagents before. It can be challenging to learn about all these different functional groups when our teacher asks us to differentiate between primary, secondary, and tertiary alkanols, as well as aldehydes and ketones, on the whiteboard (Saeed B, Student 1).

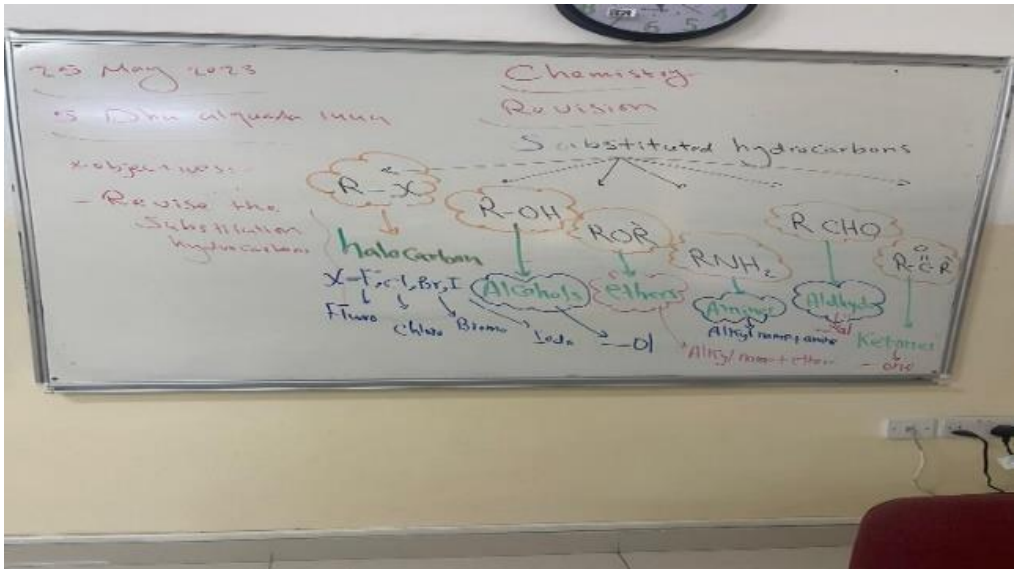

Figure 7: Differentiating Between Different Functional Groups on The Whiteboard.

4.5 Limited Lab Usage

The limited lab resources make students' understanding of OQA difficult and very superficial. Due to that limitation, teachers find themselves forced to teach the concept theoretically without conducting any hands-on lab activity. Therefore, students learning becomes more superficial and unjoyful. Here is what Amir mentioned during his interview:

"We have never used such reagents before; therefore, it can be difficult to learn something without seeing it. The color changes are something I always have to imagine and remember" (Amir C, Student 1).

That concern was further clarified during my interview with Omar:

Interviewer: *How do you understand OQA?*

Omar: Ms. OQA is abstract.

Interviewer: What do you mean by OQA is abstract?

Omar: It is too complex and complicated. It is also too many and confusing.

Interviewer: Can you explain further?

Omar: "Hmm, Ms., I'm confused by all the functional groups and reagents. It's hard to understand how two or three reagents can be used to detect one functional group. On the other hand, we always see these reagents written on the board for us. I've only seen the ones used to detect alkane, alkene, and alkyne, which is $KMnO_4$, but we don't have Benedicts' and Fehling's reagents, which make learning qualitative analysis tricky. (Omar B, Student 2).

The detrimental impact of limited lab resources on student comprehension of OQA is clearly evident. Students like Amir and Omar struggle to grasp the concepts due to the lack of hands-on experience. They describe OQA as "difficult to learn without seeing it" and "abstract," highlighting the importance of practical application for solidifying understanding. Omar's confusion regarding the sheer number of functional groups and reagents is further amplified by the absence of crucial materials like Benedict's and Fehling's solutions. This lack of practical reinforcement leads to a superficial and unenjoyable learning experience, hindering students' ability to truly grasp the intricacies of OQA.

4.6 Managing the Learning Environment

To overcome the shortage of lab equipment, teachers use pictures in PowerPoint slides and relevant illustrations to assist students in studying OQA. Furthermore, teachers try their best to make the abstract concept more understandable by engaging their students

with some simple hands-on classroom activities such as using balls and toothpicks (Figure 8)

Figure 8: Using a Foam Ball and a Toothpick to Model Functional Group Ketone.

Another strategy that teachers also use to overcome the shortage of lab materials problem is have pictures of the needed chemical compounds and bring them to the class. While observing class A boys, some students printed pictures of $KMnO_4$ and $K_2Cr_2O_7$ (Figure 9) and stacked them in their notebooks. When the teacher saw those pictures, he applauded his students and thanked them for their help (Mahmoud, a teacher).

Figure 9: Pictures of Organic Chemicals.

Results of Question 2: What are the challenges that 12th grades students face in conceptualizing OQA and how to overcome these challenges?

This question aimed to understand the challenges that 12th grades students encounter when studying the concept of (OQA) and how these challenges can be overcome. To answer this question, I observed two chemistry teachers in action as they teach OQA lessons to investigate this concept. I also interviewed teachers and students before and after delivering these lessons to gather more information. In the following paragraphs, I will discuss multiple challenges that 12th grade chemistry students face while trying to conceptualize the OQA concept.

4.7 Lack of Adequate Teaching and Learning Materials

The lack of sufficient teaching and learning materials often creates a crucial challenge for UAE's 12th grade students to conceptualize OQA. Inadequate availability of up-to-date and extensive resources limits students' ability and performance to conceptualize and grasp the underlying ideas of complex phenomena related to OQA.

Such shortage widens the gap between their theoretical understanding of the concept and its real-life applications. The lack of adequate teaching and learning materials has resulted in the adopting of a range of instructional approaches rather than practical-based methods. To help students' study OQA, some teachers use the expository process to teach OQA to students. For example, Mahmoud mentioned that:

"I often teach using regular whiteboard illustration, and sometimes, I print out pictures of these organic chemicals like $KMnO_4$ and $K_2Cr_2O_7$ and show them to my students while teaching OQA." (Mahmoud, a teacher).

Furthermore, Mahmoud sometimes makes use of several available animations and virtual lab tools to support his student's understanding of OQA:

"Also, sometimes … Since we do not possess the necessary chemicals or reagents to identify these functional groups, I mostly instruct my students on this subject through the use of organic models, videos (animations), and virtual labs" (Mahmoud, a teacher).

When asked why he did not follow his lesson plan, Mahmoud argues there is no need to have a lesson plan in hand while teaching. When asked to elaborate on that, he mentioned:

"Why do I need a lesson plan? I change the plans several times based on the available organic chemicals and reagents that we have in the lab. So, sometimes I use plan b and c as I expect my students to understand the topic, so I do my best using the models and animations better than using nothing." (Mahmoud, a teacher).

Students' interviews also underlined another major issue with the availability of the chemical reagents. They often get contaminated during the experiment as students are new to experimentation. However, those reagents need to be replaced with new ones, but the school does not provide new materials for practical activities.

Interviewing class A, students corroborated their teacher's assertion that some reagents got contaminated. When asked why their experiments were not getting successful, they said:

"Since this was our first time practicing an organic practical experiment, the class was a mess. The only issue that some of my friends rushed and accidentally used separate droppers in the same reagent container, contaminating them. That's why, for example, I didn't see the predicted colour changes, but overall, I've liked working on practical organic projects, so this purple $KMnO_4$ colour disappearance is very beautiful and straightforward. We should conduct more trials to make organic chemistry simpler and more accessible." (Class A, Student 1)

4.8 Issues in Instructional Methods Usage in the Classroom

One of the primary factors contributing to students' struggles with learning OQA is the instructional teaching methods used in the classroom. After conducting lesson observations and interviews with grade 12^{th} students, it became evident that the two teachers needed to be more concerned about the effectiveness of their current instructional approaches. They firmly believed that a practical-based teaching process, incorporating hands-on activities and laboratory interactions with chemicals, reagents, and equipment, would be the most suitable method for effectively teaching the concepts of OQA. One of the teachers mentioned;

"Students must take an active role in using the reagents and chemicals while in the lab. As a result, the subject of qualitative analysis becomes more accessible. In my opinion,

they should be able to grasp it with the support of ongoing practical instruction. In my classes on OQA, I make sure my students get the material by using practical examples. Reagents are not all of which we have. That's why I don't follow the lesson plan or course breakdown (our plan for the term and daily lesson plan). Also, most of the laboratory materials were unavailable in the investigation sheet, so I tried my best to explain this activity with limited regents. I use multi-based teaching methods and many teaching techniques like the lecture method and participatory approach to teaching group work." (Tariq, a teacher for class A).

After being persuaded by the students, the teacher finally brought the class (12 A) to the laboratory. Based on my observations, the teacher employed a traditional teaching method using a whiteboard and printed pictures of chemicals and reagents to explain the lesson. Some of the available chemicals and reagents in the lab were utilized during this explanation. However, only some students actively participated in the activity, possibly due to insufficient resources, such as inadequate reagents and limited experiment space. Subsequently, the teacher handed out worksheets to the students, urging them to complete them quickly due to time constraints and write their conclusions.

Upon reviewing the experiment's worksheet, I discovered that it was an observation sheet designed to identify the types of hydrocarbons present in a given mixture. This aligns with the stated objective of the lesson as per the lesson plan. However, upon further examination of the teacher's lesson plan, it became evident that the teacher needed to adhere to it. The lesson plan was titled "Identification of Hydrocarbons in a Mixture," the teacher's lesson plan in the laboratory differed from what was specified in the program. After allowing the teacher to elaborate on his lesson plan and teaching methods, he mentioned,

"As I previously mentioned, there were not enough materials in the lab, and I only fulfilled the students' request to change the learning environment and use some instructional boards in the lab so it can help them understand the topic."

The teacher also pointed out that he wasted time taking the students to the lab, and due to their vast number, he lost control, so he preferred to teach the lesson in the

classroom. He added, *“I could have taught the same lesson in the classroom and saved time and effort.”*

4.9 Challenges of Applying Practical Lessons to Facilitate Understanding

Limited availability to well-equipped laboratories and updated apparatus limits practical lessons' ideal and effective integration. Despite having exceptional knowledge and experience in the field of organic chemistry, the absence of adequate resources restricts their teaching and knowledge-delivering capabilities. When one of the teachers was asked why students are unable to learn practical applications of theoretical knowledge, he said,

"I believe that it is difficult for the students to understand OQA from practical lessons because they do not provide hands-on experience, thus limiting students’ ability to capture the whole idea effectively. Therefore, it is necessary to have most of the organic chemicals and reagents in the labs.” (Mahmoud, a teacher).

The teachers also mentioned the need for unified support, as teaching students through theoretical knowledge has become difficult. Tareq, one of the teachers, explained that he has a strong commitment to his goals and responsibilities as a teacher but can still not deliver adequate knowledge and learning to the students. He said;

"Dear Ms, I kindly request that we converse as a unified family. We have a long history of working together for over a decade, and you hold the position of Head of Department. Your original chemistry specialization makes you well aware of my background. In this school, most individuals comprehend the prevailing situation. Teaching this subject has been my responsibility for nine years, and my students consistently face challenges in grasping its intricate nature. Despite my utmost efforts, employing various models and practical lessons to facilitate understanding, I must admit that it has been a formidable task for me." (Tareq, a teacher)

Students from classes A, B, C, and D agreed with their teacher's assertion that practical-based instruction is not used in OQA to assist students in overcoming their difficulties with learning. One of the students asserts:

"When he is teaching a more complicated topic, such as OQA theory, he should make use of something that is visible so that we can see and feel it. For example, he may utilize practical lessons. This would be more effective than using something that is harder for us to learn and understand. Learning occurs best when I experience something directly and practice it frequently." (Class D, Student 2).

Another student elaborated on the problem, saying that they had to push themselves to understand OQA because their instructors seldom ever adopt a practical-based approach. He elaborated:

"OQA is difficult because our teacher teaching OQA without providing practical work is challenging, so I try to take notes and write it down in my chemistry notebook in the hopes that our teacher will slow down." (Figure 10).

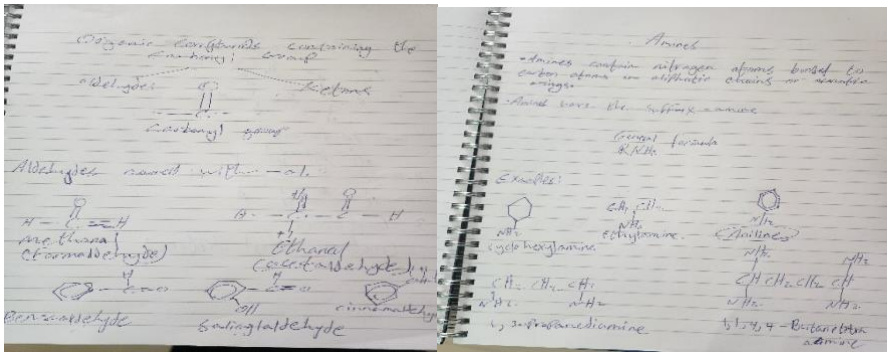

Figure 10: Sample of Students' Notes about the Functional Group, Amine and Carbonyl Group.

"I find it difficult to learn concepts in OQA without practically seeing and doing them. Learning from pictures and books makes it quite difficult, and due to a smaller number of lessons and lab visits per week, it becomes difficult for most of the students to understand the concepts fully." (Class C, Student 2)

4.10 School Financial Issues

Some UAE private high schools' financial issues highly impact educational quality as they cannot organize sufficient budgets for integrating up-to-date learning materials. The schools' financial problems make it impossible for them to arrange new reagents and chemicals to carry out practical activities. Here are a few quotes from teacher Tariq:

Interviewer: Okay, sir. If you could go back in time, what would you change?

Tariq: Practical work. In my opinion, hands-on experience is more beneficial than classroom instruction of abstract concepts. I promise to prepare these reagents in advance of our next class meeting.

When teacher Tariq asked the lab technician to write down these reagents to bring them next time, but the lab technician looked at me and smiled. The lab technician responded to me during his interview:

"Ms. whenever I try my best and send emails, (Figure 11)there is no answer—nothing in my hand. The school doesn't want to pay any money, and I can show you emails if you want." (Lab technician)

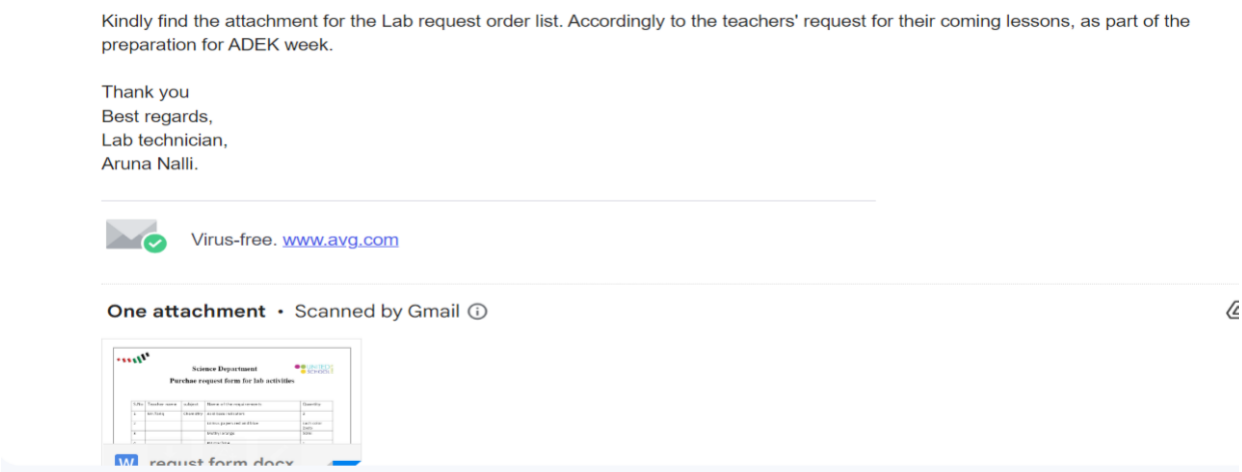

Figure 11: Purchase Request Email for Chemistry Lab

The student from class C interviewed after the lesson commented: *"Lesson was very successful. I understood those functional groups, but I thought we would do experiments; I hope so." (Class C, Student 2).*

In the second week of observing chemistry teachers and grade 12th students, I also observed sections A, B, C, and D. I felt something different in week two. When I observed Mahmoud, a chemistry teacher, again in 12 A, he taught OQA with experiments and involved students throughout the practical process. However, integrating practical activities also created a few problems, as few chemicals were contaminated, and due to

lack of adequate lab space due to inadequate school financial resources, working with many students has become quite difficult for him. An extract of our interaction after the lesson is:

Interviewer: Dear Mr. Mahmoud, how was today's lesson?

Mahmoud: Since you see it first-hand, I believe so.

Interviewer: If you could go back in time, what would you change?

Mahmoud: You could see that some of the chemicals, especially the acidified permanganate, were contaminated in the later portion, so few were achieving the appropriate results; hence, I will ensure that the class is well-controlled.

Interviewer: Tell me how that occurred, sir?

Mahmoud: Actually, I saw that a few of my classmates used many droppers to mix the chemicals. Sometimes, it happens due to their numbers; if you remember, I told you a vast number of students and a small lab area (Figure 12), so I need to manage these students well, and the most important thing is safety.

Figure 12: Small Lab Area.

Tareq, a D class teacher, introduced OQA by going over what the students already knew, getting them interested, and explaining the principles in great depth using examples

from their own lives—but alas, no animations or models. Our conversation is summarized as follows:

Interviewer: Excuse me, sir, Is everything well with the lesson?

Tareq: Yes, Miss, it was a success.

Interviewer: Could you elucidate this further, please?

Tareq: I learned it from the students' responses and comments.

Interviewer: Excuse me, but you never used the models and animations that you had promised.

Tareq: Hmm, I completely disregarded them... Nonetheless, I will do every effort to include them into our upcoming meeting.

As early as grade D, students were demanding that, in the event that traditional teaching resources were insufficient, their OQA classes make use of animations and models. Students thought this method may be useful in getting over their learning disabilities. As one of my classmates put it,

Miss "Our teachers usually explain lessons very well, but still doing it practically explains it even better. I remember once he taught us hybridization, and he explained it with the help of videos. It became quite easy and simple for me to understand it fully. So, practical work and pictures or videos aid a lot in enhancing my understanding." (Class D, Student 1)

Only in Class A did the instructor really implement his pre-lesson plans for the 12th grade chemistry class; the other three classes (B, C, and D) taught by teachers in their second week did not. According to student feedback, these behaviours influenced how well they understood OQA.

4.11 Teaching Language Challenges

The interview highlighted teacher language challenges as crucial in understanding and conceptualizing the knowledge by the 12th-grade chemistry students in acknowledging the OQA. Students found difficulty in understanding instructional material during lectures

and practical activities as well and wanted a language-rich learning environment to cope with their challenges with the English language. My interactions with students before some lesson observations are:

Interviewer: What would you expect if you were learning OQA today?

Majed: I want our teacher to help me understand even if he needs to translate some words and concepts (the student is weak in English); I wish we all had the chance to do experiments. There was no shortage of material, and I wanted the class to be dull and consisted solely of explanations. (Ms. I'm telling you something secret, you know sometimes I feel lost, especially when the teacher talks in English, so I start drawing better than nothing). Additionally, he should use models and animations to aid comprehension; seeing things helps more than hearing about them. (Class A, Student 2).

Before starting my lesson observation in class 12 A, I also asked the teacher, Mahmoud, what I should expect from this lesson on OQA for today. He answered, "*I'd include students in the regular whiteboard drawings with markers*." But I didn't understand what he meant exactly, and I asked him to elaborate. He said, "*Before starting today's lesson, I'll review what they already know. (Previous knowledge) Considering that we can't do practical lessons due to a shortage of reagents, I will also take my time & explain in detail so they can comprehend. The only opportunities for student interaction in this teacher's classes were with the teacher's questions and the teacher's whiteboard (marker) board drawings*."

In addition to the checklist observation, I perform a daily observation called the "wake throw" observation, which takes approximately 5 to 10 minutes. I conducted this observation regularly before beginning the checklist observation.

After completing the wake throw observation in the class of 12 D, I proceeded with the checklist observation, which could account for students. The purpose of this observation is to find out why some students need help understanding OQA. Take Tariq's class as an example; I saw that he needed a lesson plan, examples, experiments, and a way to assess the student's background knowledge. But by having them answer and solve example questions, Tariq got the students involved in what they were studying. He also provided detailed explanations of OQA concepts to the students.

4.12 Unmotivated Teacher

The interview helped me acknowledge that the teachers seem unmotivated for several reasons. Due to the unavailability of reagents and chemicals and small laboratory spaces, it becomes frustrating for the teachers to carry out practical activities and make students learn the concepts in a better way. However, teachers try to do their best by explicitly explaining the theoretical concepts and using available materials, such as pictures and illustrations, to make students' learning effective.

Following that lesson, I conversed with Tariq in my office and invited him to join me for a cup of coffee at my office. *I asked him "if his lesson went as expected*?" *He surprised me when he said,*

"At the start, I was not very hopeful because I was unable to carry out practical experiments, but I explained it well to my students. As the topic was complex, I tried to provide several examples of compounds to enhance students' understanding. Furthermore, to provide more understanding, I review their previous knowledge and then give compounds examples such as esters, ethanol, and other functional groups based on their earlier knowledge."

This is what a Class D student had to say when questioned after the lesson:

"*Because he thoroughly discussed those functional groups, and I grasped what he was teaching, the class was effective. However, I would better understand if we had completed hands-on activities. Therefore, I will independently observe and complete that task." (class D, Student 1).*

Analysing teacher Tariq's teaching plans, I found that he always tries to locate the students' previous knowledge and modify his lectures accordingly to enhance students' knowledge. However, due to a lack of instruments and materials required for practical experimentation, he was unable to teach the OQA concepts effectively. We have a segment from our conversation with the teacher, Tariq.

Interviewer: "Welcome back, Mr. Tariq, from the lesson".

Tariq: "Thank you."

Then I tried to be friendly with the teacher because I felt he was tired and not motivated to discuss and reflect on his lesson, but I asked him, *"Did the lesson go as expected?"*

"What do you think?" He smiled and answered, *"It was very, very successful"*. But I needed to understand what he meant exactly, Then I asked him to explain further.

Tariq: *"Ms., you were present and witnessed everything. My students were actively interested, I provided them with a thorough explanation of the functional groups and their responses, and I even handed out the necessary notes. Their answers and participation indicate that the lesson was successful"*

Interviewer: "I see. I thought you said in the introduction that we would learn how to identify such functional groupings in this class through experiments."

Tariq: "To be sure, I kept my word. At first, I was under the impression that I could procure the necessary reagents—such as Tollen's reagent and dichromate ($K_2Cr_2O_7$)—to prepare the aldehydes and alkanols, but I couldn't find them in lab cabinet (you can also ask the lab technician). Also, as you can see, the taps are not flowing (Figure 13) small lab area (as he opened one of the lab's taps). I've had a hectic day with five out of six classes and two additional duties. It's been quite exhausting. Nonetheless, even without the experiments, the students grasped the concepts."

Figure 13: The Taps Are Not Flowing in a Chemistry Lab.

Results of Question 3: What sort of support do 12th grade students need to better understand OQA?

This research question aimed to discover what kind of help 12th grade students require to improve their understanding of OQA. To answer this question, I focused on delving into the viewpoints of both teachers and students regarding OQA content in the context of the official curriculum. I aimed to comprehend their perspectives on how well the curriculum matches the content and teaching techniques applied in OQA lessons. The following paragraphs present students' perspectives on the support they need to better understand OQA.

4.13 Reconsidering the Nature of the Chemistry Textbook

The curriculum's content, chemistry curriculum's nature, and time subject is expected to be taught were other factors noted by the two chemistry teachers and grade 12 students that explain their difficulties conceptualizing OQA in connection to teaching & learning. OQA's substance was extensive and abstract. Here is an excerpt from teacher Tariq:

*"In all my teaching experience, this topic has been always found difficult by students because of its nature (*Figure 14). *Year after year, I have tried to explain it effectively, but due to small lab areas and the unavailability of chemical compounds and reagents, it has become very difficult for me. I use models, animations, and videos. But still, it is not easy." (Tareq, a teacher)*

Tariq believes that to teach OQA effectively, teachers need more support. He suggests organizing workshops specifically for teaching tough topics like OQA. These workshops should show successful teaching methods, including hands-on activities. Teachers also need access to good labs, teaching materials, and model kits.

Tariq thinks technology, like virtual labs, can help, and teachers should be trained to use it well. He suggests a flexible curriculum, continuous assessments, and feedback to allow teachers to explore complex topics like OQA. Collaboration among chemistry teachers and mentoring programs can also be helpful.

Tariq recommends creating support teams in school, providing ongoing training, and establishing a budget for better lab equipment to improve the situation. He also suggests using real-life examples to make the content more relatable to students.

In short, Tariq believes that by following these suggestions, schools can better support teachers in teaching OQA effectively.

#	Mon	WEE	Value	Competency	National identity domain	We Are Learning
1	January 2023	02-01-23 06-01-23	Respect	Collaboration/teamwork	Citizenship	Model 20 – Hydrocarbon Lesson 1– Introduction to hydrocarbon
2		09-01-23 13-01-23	Respect	Collaboration/teamwork	Citizenship	Model 20 – Hydrocarbon Lesson 1– Introduction to hydrocarbon
3		16-01-23 20-01-23	Integrity	Communication	Values	Model 20 – Hydrocarbon Lesson 2– Alkane
4		23-01-23 27-01-23	Integrity	Communication	Values	Model 20 – Hydrocarbon Lesson 2– Alkane
5		30-01-23 03-02-23	Integrity	Communication	Community	Model 20 – Hydrocarbon Lesson 3– Alkene and alkyne
6	February 2023	06-02-23 10-02-23	Integrity	Initiative/self-direction	Culture	Model 20 – Hydrocarbon Lesson 3– Alkene and alkyne
7		13-02-23 17-02-23	Empathy	Initiative/self-direction	Culture	Model 20 – Hydrocarbon Lesson 4 – Hydrocarbon isomers
8		20-02-23 24-02-23	Empathy	Entrepreneurship	History	Model 20 – Hydrocarbon Lesson 4 – Hydrocarbon isomers
9		27-02-23 03-03-23	Empathy	Entrepreneurship	Citizenship	Model 20 – Hydrocarbon Lesson 5 – Aromatic hydrocarbon
10	March 2023	06-03-23 10-03-23	Empathy	Entrepreneurship	Citizenship	Model 20 – Hydrocarbon Lesson 5 – Aromatic hydrocarbon

Figure 14: Term Plan (Course Breakdown).

4.14 Devoting More Time to Teach the Topic

According to the two chemistry teachers, the OQA topic is extensive, but they prefer to teach it during the second term of the academic year. This timing is chosen because many students require a solid understanding of this topic for the international exam. The examination council includes a few questions related to this topic in the exam, making it crucial for students to be well-prepared. The teacher needs to consider presenting

the topic of OQA to students before taking their EmSAT[1]. However, some students believe it has a complex structure; therefore, it should be taught right from term 1.

Amir, one of the students, believes that organic chemistry, specifically OQA, should be introduced earlier in the academic year, spanning from term 1 to term 3. He emphasizes the abstract and voluminous nature of the subject, expressing concern about the confusion that arises when learning it later in grade 12. Amir argues that by starting OQA in term 1, students would have ample time to comprehend the topic's complexities, creating a solid foundation for subsequent terms and better preparing them for the international exam. In essence, Amir advocates for an early introduction to OQA to facilitate a deeper understanding and alleviate the challenges of learning this intricate subject later in the academic year.

At the same time, another student, Ahmed, agrees with the teachers who prefer teaching OQA in the second term. Ahmed thinks the timing is essential, mainly because OQA is extensive and crucial for the international exam. This matches the teachers' plan to concentrate on OQA nearer the exam time.

When asked about his view, Amir and Ahmed said,

Amir Specifically, I think we should begin learning qualitative analysis in organic chemistry in the first three terms of the course so that everyone is on the same page. They are dense and difficult to grasp, and teacher also waited till the final year, grade 12, to explain why we didn't take Introduction in grade 11. Hence, we had plenty of time to understand this complicated topic, not just in grade 12 and second term, soon enough, he began flooding us with functional group detections. Whenever I begin to study it, I get confused. (Class C, Student 1).

Ahmed The chemistry teachers reserve organic chemistry as the last topic to teach, and because there's not much time left before exams, he hurries through the lessons. Because chemistry has a lot of information, I admit to sometimes memorizing it without really

[1] EmSAT- The Emirates Standardized Test is a national system of standardized computer-based tests, based on United Arab Emirates national standards.

understanding it. I sometimes remember it, trying to understand it, but it doesn't stick. (Class A, Student 1)

In the UAE, a new assessment test called "EmSAT Achieve Chemistry" is designed for high school students. This test aims to evaluate students' proficiency in Chemistry and is aligned with the UAE's National Curriculum. "EmSAT Achieve Chemistry" is available in English and Arabic and is administered by the MOE. It is open to all high school students in the UAE and is offered twice per year. "EmSAT achieving Chemistry" is essential as an assessment tool as it enhances students' achievement in Chemistry (Figure 15). Its primary goal is ensuring all students have the knowledge and abilities required to succeed in higher education. By implementing this test, the education system in the UAE aims to foster academic growth and provide students with a solid foundation in Chemistry.

Also, non-Emirati students need it in the SAT2 exam (7 subjects and one of these subjects, chemistry), and all the students need this topic in the foundation year in the university. *The teacher said,*

"Because in the EMSAT final examination, the MOE mostly includes more organic topics than inorganic ones. I hardly teach OQA early, so I put them in second term because lots of questions come from that facet (organic), and if I need more time, I will change the plan and continue giving this topic in the third term for the importance of this topic and as I mentioned before it is heavy and hard. Hence, we need more time to cover the required." (Tareq, a teacher)

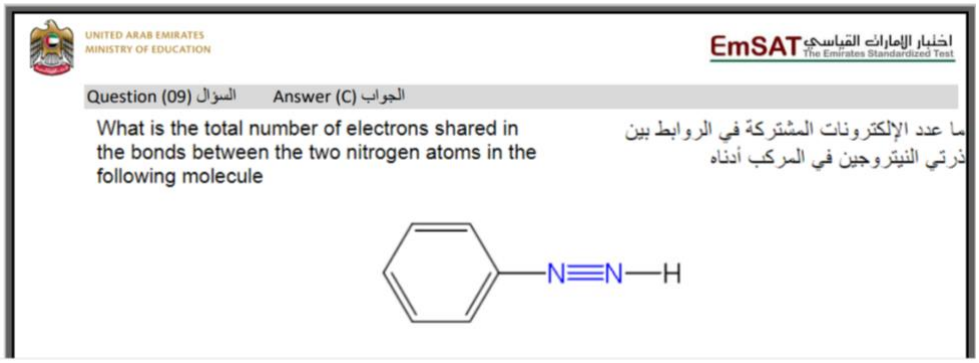

Figure 15: Sample of Hydrocarbon Question in Chemistry EMSAT Exam

OQA is taught in the second term, and teachers continue teaching it in the third term to help their students overcome some of their learning difficulties. It is also easy for them to remember the topic when they take the EMSAT exam at the end of the year. But high performers were the only ones who benefited from this tactic. When inquired by a teacher, he said,'

"As a result, they find it simple, leaving us with no choice. This method is useful for students who are already doing well in chemistry because there is no way that we will ever be able to cover all of the material. The one and only drawback is that I occasionally get it done quickly." (Tareq, a teacher).

4.15 Conceptualize OQA and Other Concepts in Organic Chemistry

Conceptualizing OQA is difficult for students as it requires techniques to locate and characterize organic compounds. Students mentioned that the OQA includes functional group and solubility tests, which require more profound understanding and continued practice. The interviewees from classes D and C agreed with Tareq, the chemistry instructor, that the students had trouble understanding OQA because of the timing and kind of the lesson. The following are the students' views;

Rawaa: Studying and comprehending OQA is incredibly complex, sophisticated, and hard. Rawaa expresses that OQA needs to be more explicit; they feel that OQA is too abstract, complex, and complicated, suggesting that it might be more suitable for university-level learning, especially for those pursuing pure Chemistry. RAWA suggests removing OQA from their syllabus (Class D, Student, 2) Meanwhile, Omar supports Amir's suggestion, which advocates introducing OQA teaching starting from term 1. Much like Amir, Omar acknowledges the potential complexity of OQA and may emphasize the benefits of an early commencement. He could argue that initiating the topic early enables students to progressively grasp its intricacies, leading to a more comprehensive understanding when the exam approaches.

*OMAR**:** Teachers are scrambling at the last minute to teach this complex subject, particularly the alkenes, alkynes, and alkanes. I won't even grasp it. Ms, please, was it like that during your time? He laughs…" (School B, Student 2).*

The outcomes from student interviews present a nuanced comprehension of varied viewpoints regarding the optimal timing for instructing OQA. The student interviews shed light on different opinions about the best time to teach OQA. For instance, Ahmed and perhaps Rawa, point to the importance of timing, especially in the second term, in order to be well-prepared for the exams. On the other side of the argument, students like Amir and probably Omar strongly recommend the early start of OQA to address the complexities some people have with this kind of system.

The studies by Anim-Eduful and Adu-Gyamfi (2022) also give similar results, indicating that OQA is difficult to comprehend. The research elucidates the significance of using qualitative methods to get to the root of the problem hampering academic achievement (Adu-Gyamfi et al., 2022). As stressed by Cresswell (2009), qualitative research is very important for examining intricate phenomena for data that goes beyond the ability of quantitative methods to achieve. When employing qualitative techniques such as personal interviews corresponds with Cresswell's view of deep issues being thoroughly investigated.

The results from the interviews with the students also reflect on the struggles that the students face in learning OQA, as has been revealed in some research and literature. These findings thereby accentuate the significance of factoring in different perspectives while creating curricula. Providing learning strategies that accommodate various learning approaches and give students all the necessary tools to prepare them for exams is an integral part of the process.

4.16 Data Analysis (Case Study)

The qualitative part of the study included a second type of analysis which involved case studies. The aim was to address the complexity of students in learning OQA and to provide a detailed description of the factors that affect their learning and understanding of this topic's rhizomatic nature of their works practices. The student was selected for this case study as her work practices stood out from the others and were clearly rhizomatic. The student is from a different background mentioned something different than others. She talked about language and how it affects her understanding of the topic, and she

mentioned something essential for the teaching and learning relationship between the student and the teacher.

Additionally, I saw that the student was distinct from others when I observed her classrooms since she mentioned several things that set them apart. And how she interacts with the teacher and chats with others stimulates my curiosity to learn more about her, her backgrounds, and her uninterest in studying chemistry. Since this is her first year in this school, she assisted me in identifying new and unique evidence that supports my study. She also focused on the spaces between the inside and outside school work practices, the influence of affinity groups on students' engagement with certain work practices, and the processes involved in filling gaps in one form with another.

In short, Rawaa's case study provides detailed answers to three critical questions:

1. What makes it easier or harder for 12th grade students in the UAE to understand OQA? Rawaa shares her experiences and factors that influenced her chemistry learning in grade 12.
2. What difficulties do 12th grade students encounter when grasping OQA, and how can these difficulties be overcome? Rawaa talks about specific challenges she faced, some of which other students might have forgotten. She also discusses ways to overcome these challenges.
3. What kind of support do 12th grade students need to improve their understanding of OQA? Rawaa discusses academic support and highlights the importance of well-being and fitting into the 12th grade environment and the school as a whole.

4.16.1 The Story of Rawaa (Case Study)

Rawaa (pseudonym) was the first to respond to my request for participants from the grade 12 students in the first interview with eight students, and Rawaa was chosen for the case study, as I mentioned before, for many reasons; I then called Rawaa to verify that she is from grade 12 girls' students. We scheduled her interview appointment according to her availability, significantly since her interview was at the end of semester two, and this is the final exam time. Still, when I called her, she didn't mind, and she was the first

to respond, as I mentioned before, compared with other students who were selected for interview.

Rawaa recommended after 1:00 p.m. so that she would not interrupt her study hours in school, especially since the student has extra classes every day practicing for the next day's final exam; so, after she had done. She agreed to meet me on the school campus, in my office in the girl's section. When she arrived at my office, I was waiting for her and was the only one present in the office. I observed that she was nervous as she was fidgeting with her hands. I asked her to select any seat around the conference table, and she chose the chair closest to the door.

As an introduction, I told her a little about myself and expressed my curiosity in the study in which she would be taking part. I reassured her that she was under no need to answer any question that made her feel uncomfortable. I got the go-ahead to initiate talking by obtaining written and verbal consent, and I set up my notebook on the table in a strategic manner to start writing. This interview lasted 30 minutes.

4.16.2 Rawaa Background and Language

Upon initial observation, Rawaa appeared to be a timid and introverted individual. Born on September 10th, 2005, she was 17 years old during our interview. Growing up in a bustling city in the United States, specifically Texas, her native language is English. However, her proficiency in Arabic could be improved, as she only knows a few words and primarily communicates in an American accent. She began by talking about her family structure and her upbringing. During the earlier years of her life, her immediate family lived with her father's grandparents due to financial struggles and because her dad during that period was a full-time student. Her immediate family consisted of her father, mother, an older sister, and a younger brother. She was the middle child of the family. Her voice brimmed with excitement as she recounted her family's experience of moving into a home her father had personally constructed on a spacious half-acre plot once their financial situation had stabilized. However, her tone turned somber as she revealed they had only resided in the new house for a mere year. Their departure was due to her father's completion of his education in the United States, having earned his associate's degree in

medicine. Subsequently, he secured a remarkable job opportunity as a doctor in the United Arab Emirates, prompting the family's relocation to the Middle East.

According to Rawaa, initially, she was excited about living in Arab countries due to her family's connection to Iraq. Her father's grandfather hailed from Iraq, but due to the circumstances of war long ago, they moved to the United States and established their lives there. Rawaa candidly admitted, "To be honest with you, I don't know much about my country, Iraq, but I've heard from my grandparents that it's a beautiful place. Unfortunately, we can no longer reside there, so my dad relocated to an Arab country, although it's not our homeland." Consequently, he deemed Abu Dhabi, an excellent choice for the entire family, and four years ago, we moved when I was in 9th grade.

During Rawaa's fourth grade, her parents divorced, which compelled her father to return to his grandfather's house with her and her two siblings. Her father pursued higher education and obtained a bachelor's degree in medicine. This achievement led him to secure a good job in Abu Dhabi, where he worked for the first four years. However, the entire family relocated to Al Ain this year because her father is currently employed at Twam Hospital. As a result, this marks her first year in Al Ain City and this school.

As for my mom, Rawaa says, she does not live with us. She remains in the United States. Although she holds a bachelor’s degree in psychology, she does not work in her field. Instead, she works part-time as a nurse for a Senior Citizen's home and as a library aid for a middle school.

4.16.3 Rawaa Parental Expectations and Aspirations for Education

Rawaa went into detail about her elementary and middle school experience that directed her about attending American school in grade 12 in high school and pursuing her degree in grade 12, especially in chemistry science. Her dad encouraged her to attend an elite high school in Texas. It was considered an early college high school in conjunction with a Community College, and the curriculum was highly challenging and counted as both high school credits and college credits. She stated she hesitated to apply during her eighth-grade year because she did not feel she was smart enough. As she spoke of her acceptance into the elite high school, she was excited to say that she was among the top

10% of high school students in this large city to be accepted into this elite school. She chuckled as she said many of her friends that were not accepted called her a "Nerd."

Her curriculum at the elite high school was a difficult one. Students accepted were required to enroll in both high school and college level credits at the same time. This type of education required a great deal of time and task management to balance high school coursework, college coursework, and her personal life. She endured a challenge through the first year of high school in grade 8 as she strived for A and B grades. She spoke of the pride she had within as she conquered the challenge by earning a college course while she is still in high school. Rawaa was very humble as she stated,

I wouldn't say I like to show off that I had already earned college-level credits when I graduated from grade 8. This is because only some have been given the opportunity to get college-level credit in education while in grade 8 high school. I have pride, and I don't rub it into anyone. (Rawaa, personal communication, March 13, 2023, second semester)

The curriculum she went on to expand on was college-bound courses. She completed a course in English and a course foundation in chemistry. She stated that her challenge was her chemistry class because she had to complete the college-level introduction to chemistry class to complete the associate's degree. She took the required placement exam and received a 51% or higher score to get placed in college-level science. She succeeded only at the beginning of her grade eight academic years.

As Rawaa transitioned to live with her family in Abu Dhabi, she said she didn't choose to live in the UAE. It's her dad's and family's choice, as she believed it was better due to her family's financial status and it's a better choice for the whole family. Still, she feels sorry about herself because she likes to continue what she started in the United State.

She expressed her surprise upon learning that the program she had initially enrolled in the United States, which allowed high school students to take college courses, did not exist in the UAE. Regretfully, she recounted her dedicated efforts and hard work during eighth grade when she joined the university to participate in that program and take relevant courses. However, her current situation in the UAE, where she attends an American school as a ninth grader, is different. The educational program in the United States varies from

that in the UAE. Despite the challenges, she strives diligently to connect with fellow students.

She further shared that her deep interest influenced her choice of a college major in the United States in animals. Her fascination with watching Animal Planet and the enchantment she experienced while observing animals profoundly impacted her. During high school, she cared for pets and found joy in this responsibility, which brought her happiness. One memorable incident occurred during her eighth-grade class, where they watched a movie about illegal poaching. This disheartened her, knowing that such actions were prevalent in society, and she resolved to make a positive impact by safeguarding animals. With conviction, she declared, "This is my calling, and this is what I am going to do" (Rawaa, personal communication, April 13, 2023).

Rawaa mentioned feeling well-prepared due to the two college courses she had taken while still in high school, which she completed while attending a prestigious high school in Texas. Despite having these two courses under her belt, she was still classified as a first-time fresh at the American school she attended, marking her first year in this new educational environment. However, she was granted credit toward her diploma for the courses she had previously taken.

In addition, Rawaa took the EmSAT and SAT exams and scored well in both. Furthermore, her final high school grade in first and second semester point average stood at an impressive above 90.00.

4.16.4 Rawaa Grade 12 Experience & Difficulties in Learning Chemistry

Rawaa then proceeded to talk about her grade 12th experience. She believed that she was ready for grade 12th life and coursework, but after her first two semesters, she realized that she was not ready for the last semester in grade 12 and the university yet. She commented*, "I feel I'm struggling this semester and no motivation at all "(Rawaa, personal communication, May 13, 2023).*

All the students in grade 12th are currently discussing the challenges they face in learning OQA. However, it is worth noting that Rawaa, as I have previously mentioned, consistently brings up specific difficulties during these discussions. The other students do

not say these particular challenges, making Rawaa stand out as the primary student who openly shares her obstacles. According to the (Figure 16) provided by NVIVO, Rawaa's concerns about learning OQA surpass those of her classmates.

Additionally, in the (Figure 17), Rawaa has chosen a unique set of topics to discuss, focusing solely on her own experiences. This individualistic approach sets her apart from the other students and highlights her distinctiveness. As a researcher, Rawaa's perspectives can greatly assist me in my research endeavours. Her insights may uncover new aspects and contribute valuable information to enhance my work.

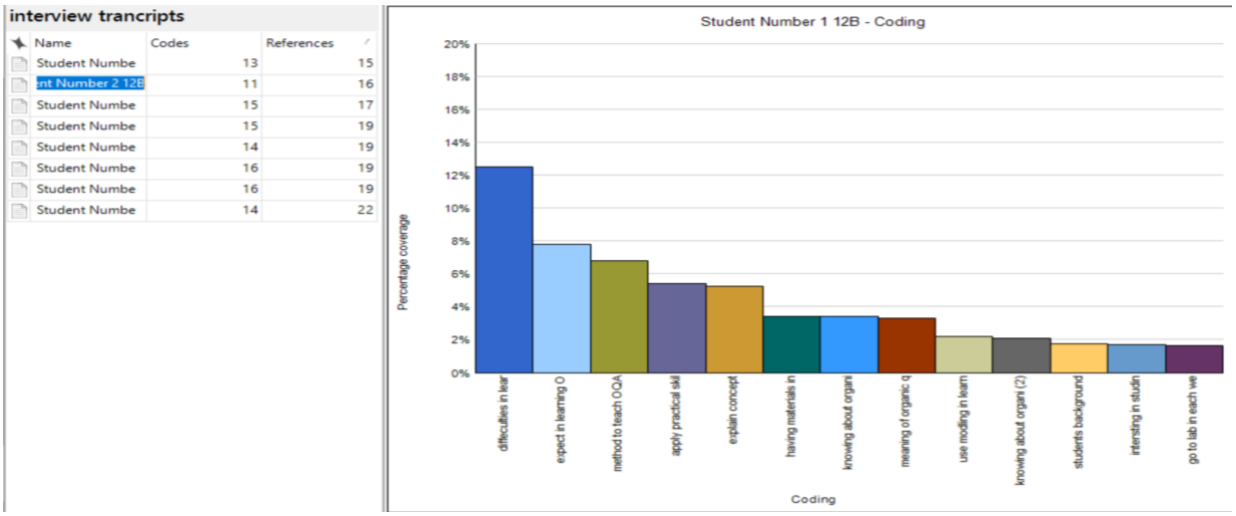

Figure 16: Rawaa, Most of The Students Talk About Difficulties Compared with Other Students.

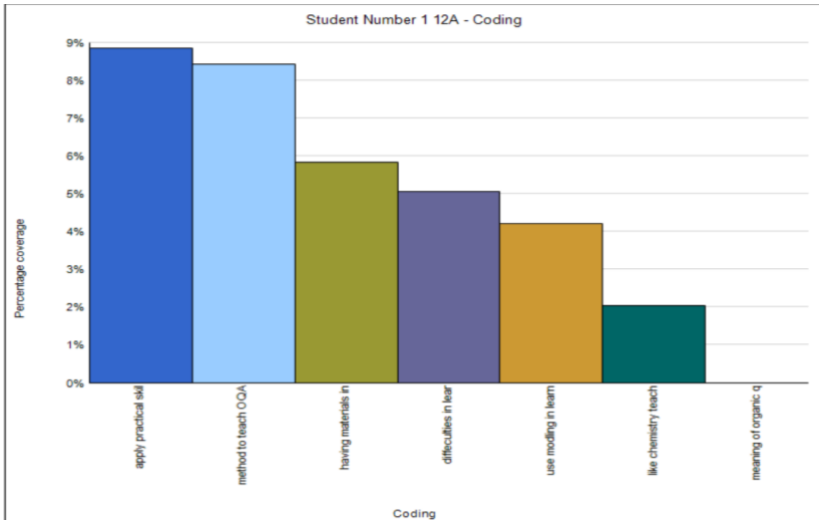

Figure 17: Chosen a Unique Set of Topics to Discuss

As Rawaa recounted her experience, a tinge of disappointment could be heard in her voice. Her final exam and preparation coincided with the arrival of numerous new students in her class during the second and third semester. Assigned to a group with seven other students, she was handed a stack of papers. The chemistry teacher instructed them to independently solve the worksheets as quickly as possible and submit the answers by the end of the week. These eight worksheets were to be considered homework by the teacher.

Left to her own devices, Rawaa did her best to create her answers and find the correct solutions. However, she expressed feeling lost because the chemistry teacher went through the material rapidly, particularly regarding naming functional groups. Rawaa believed that the teacher needed to slow down, as functional groups were not an easy topic and required more time for comprehension.

4.16.5 Language Capability

Connecting Rawaa case study with the literature review, one of the factors that can impact how well students learn about OQA is their language proficiency. Apart from how students feel about it, other things can affect how well students learn about OQA in chemistry. One crucial factor is their language skills. Some studies have examined how classroom language can make it easier or harder for students to understand and do well in chemistry (Alieto, 2018; Beka, 2016; Macaro, 2019). This is especially important in the UAE because many teachers come from different countries where English is spoken differently, which might differ from what Emirati students are used to.

So, how well a student can use language can impact how they do in science and overall (Jarrah, 2020). Adding to her frustration, the teacher spoke in Arabic, which Rawaa needed help understanding, given that many new students in the class struggled with English and came from public schools. Rawaa had requested the teacher to explain in English, but instead of accommodating her, he began shouting at her, accusing her of wasting his time. Consequently, he sent her to the supervisor, claiming she was disrespectful and aggressive towards him. Rawaa expressed her disdain for this teacher, clearly showing her negative sentiment toward him (Rawaa, personal communication, May 17, 2023).

4.16.6 Rawaa's Difficulties in the New School and Chemistry Teacher

Rawaa expressed her struggle as she transitioned from an American school in Abu Dhabi to her current school, which was filled with new students and uncooperative teachers. She found navigating the classes required for her grade 12 degree difficult and needed help to earn extra marks or handle the situation. The chemistry teacher, in particular, could have been more helpful and consistently spoke in Arabic, as mentioned earlier, due to most local students requesting explanations in Arabic. Whenever Rawaa tried to communicate with him in English, he would become angry, ignoring her and refusing to explain in either language. This posed a significant challenge for her, leading to her strong dislike for the chemistry teacher, whom she described as mean (Rawaa, personal communication).

Furthermore, Rawaa blamed her chemistry teacher for being unfamiliar with transfer students' challenges in a new school and environment and for needing more effective communication with her and her parents. She particularly needed assistance in chemistry, but she vividly remembers how she left her struggling alone at the table while trying to solve the worksheet.

And she adds I don't like chemistry teachers at all. (Figure 18) below, which shows (case classification by using NVIVO, which shows Rawaa, unlike the chemistry teacher and she, has a bad relationship with him.

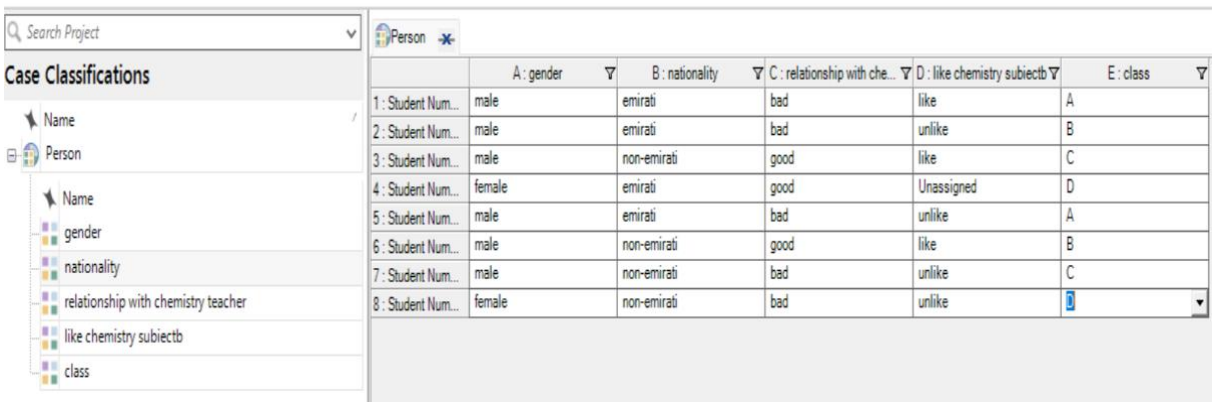

Figure 18: Support and guidance to assist Rawaa in improving her understanding of OQA.

Seeking guidance, Rawaa turned to another chemistry teacher willing to communicate with her in English. With his help, she successfully completed her first semester and scored well.

In November, as the second semester approached, Rawaa faced familiar struggles. Determined to seek guidance, she turned to the available resources at her school, specifically reaching out to the Science department. Coincidentally, during a parent meeting to discuss the upcoming second-term exams, Rawaa had the opportunity to meet with her chemistry teachers, including the head of the department. In this meeting, she once again received advice from her chemistry teacher, who happened to be present. However, to her frustration, Rawaa was given a list of materials she needed to cover for the upcoming semester.

When Rawaa attempted to attend chemistry classes in the second term, she discovered that many topics needed to be covered. It became apparent that the three chemistry classes offered were insufficient, and additional chemistry classes were necessary to cover all the required material for the second semester. Rawaa communicated her frustration, and her chemistry teacher, start rushing again to cover as much as possible given the circumstances. This unexpected situation presented a significant challenge for Rawaa and intensified her frustration. (Rawaa, personal communication).

4.16.7 Rawaa Relationship with Teachers

Upon completion semester 2, Rawaa was disappointed in her grades. She attributed the unsatisfactory grades to lack of communication between the teachers and herself. The first class that Rawaa discussed with me was chemistry, organic chemistry. she stated that she failed the subject due to the immense amount of work assignments, random quizzes given and too much homework and worksheet and a family emergency back home. With regards to her class (physics), this course to her was difficult but she did pass with a good score because content was nothing but lecture and power points. The teacher was not enthused about his teaching and this was truly a reflection on the presentation of information for the class. As she spoke of organic chemistry again (Introduction to hydrocarbon), she became enthusiastic, the teacher and she were able to communicate and she listened to him when he had questions, she received a good score in this class.

The tone of her voice became upsetting as she spoke of her class in 8G (introduction to chemistry) course. Rawaa and the instructor of this course had a disagreement based on the treatment she received in this class. One of her written midterm exams was up on the overhead for all the other students to see with her name on it and the instructor began to critique the exam paper verbally, allowing other students in the class the same opportunity to do so. When a private meeting was set up between the two, Rawaa stated she did verbalize to her how humiliated she was in front of the class. The instructor's response as Rawaa stated *"It is a college class and you have to take some sort of criticism in order to get better" (Rawaa personal communication, May 13th, 2023)*

Rawaa continued on to say that this was the treatment she received throughout the semester and quit participating in class discussions, but she was proud when she *said "I did beat her in the end, I completed the course with a B" (Rawaa, personal communication, may 13, 2023).* Rawaa proceeded to share her experiences during her third semester. In her Biology class, which focused on Genetics, she once again encountered disrespectful behaviour from her teacher. Rawaa revealed that she received a low mark on a final research project assignment and received unclear feedback (*Figure 19)* prompting the teacher to request a meeting in their office.

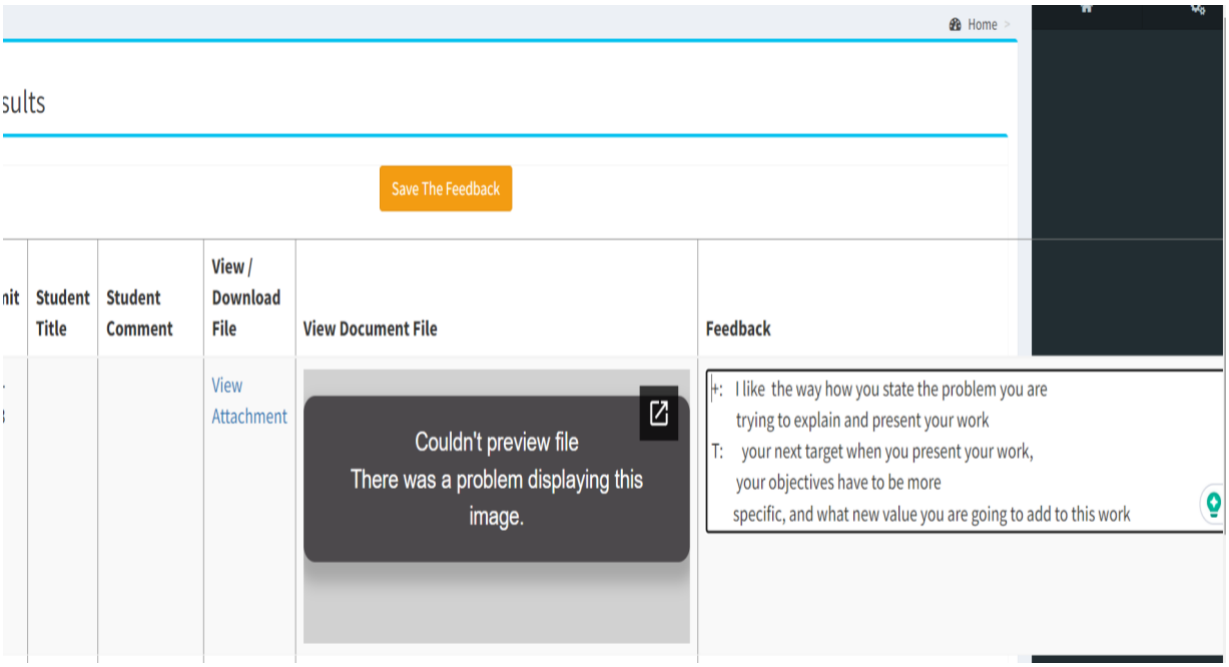

Figure 19: Rawaa final research project assignment submission throw school system and received unclear feedback.

During the meeting, the teacher criticized Rawaa's research project paper, referring to it as "dirt." Confused by this response, Rawaa explained that she had followed the teacher's recommendation by seeking assistance and feedback from the leader of their group home, who was responsible for approving and submitting the project on behalf of the group. Per the teacher's instructions, Rawaa's responsibility in the project was to finalize the ideas and hand them over to the group leader before submitting them to the teacher. However, most of the workload fell on Rawaa's shoulders, as most students needed more enthusiasm for collaborative work.

Given the deadline approaching, Rawaa chose to work independently (Figure 20) and assume their roles in addition to her own. Despite taking on this additional burden, she was blamed for aspects she had not been responsible for. She expressed her frustration, stating that she had repeatedly complained to her biology teacher about the challenges of working in a group. Still, he showed little concern and dismissed her concerns, emphasizing the necessity of teamwork for the project's completion.

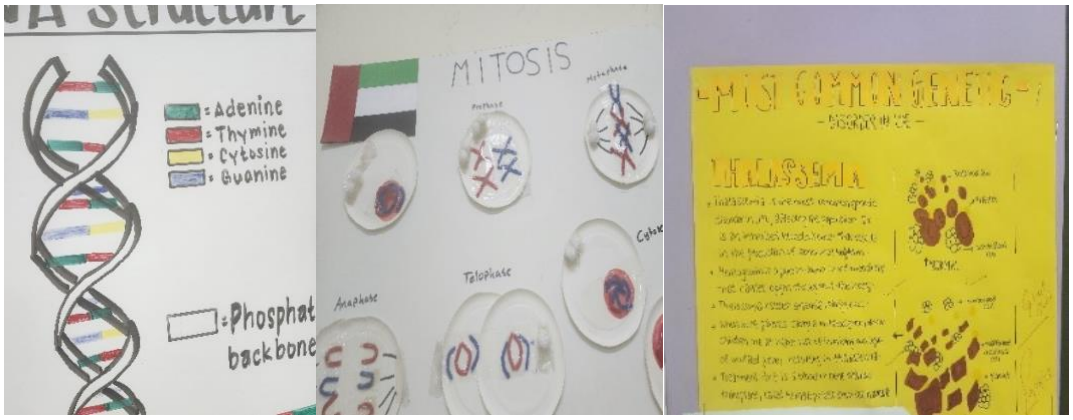

Figure 20: Rawaa's Work in Biology Project.

Expressing her dissatisfaction, Rawaa told the teacher, *"The way you speak makes it seem like you don't care about my project work" (Rawaa, personal communication, December 13th, 2023).* She also highlighted other issues she had faced, such as feeling isolated in the class with no one to talk to. Rawaa mentioned that she was the youngest student in the class and believed that her classmates bullied and made fun

of her because her Arabic skills were weak, and their English proficiency was also challenging. She wondered why they attended an American school and contemplated whether she should pursue something else (Rawaa, personal communication, December 13th, 2023).

During the remaining semester subjects, Rawaa succeeded in math (pre-calculus), earning an A. She performed well in physics (General physics), ultimately receiving a B grade. Although she felt some disappointment in herself and was not entirely satisfied with the grade, she accepted it as it was. As our conversation continued regarding her third-semester classes, Rawaa expressed that she had not been very involved in the semester due to a loss of motivation and overwhelming exhaustion. Despite her best efforts, she felt her hard work went unappreciated, especially when working in groups where most students received similar marks.

This led her to request to work individually, but the teacher refused. Furthermore, Rawaa shared that she faced pressure from her family, who constantly pushed her to study harder. She mentioned feeling burdened by the high expectations placed upon her as the top-ranked student in the class, which sometimes made her despise going to school and fostered negative feelings toward her teachers and colleagues.

4.16.8 Rawaa Challenging in School

The school has set predetermined class schedules and timings for this semester. Due to a shortage of teachers in grade 12, Rawaa has been assigned early morning classes starting at 7:00 am and late afternoon classes until 3 pm. Rawaa has shared her struggles with active participation and engagement in the classroom, stemming from previous experiences of humiliation and disappointment with teachers during the first two semesters of the academic year. Moreover, she felt older students needed to value her comments and contributions. However, Rawaa occasionally enjoys lab-related classes like chemistry, where practical experiments are limited due to defective materials. Regrettably, the school's labs, including those for physics and biology, suffer from inadequate resources, as both teachers and students, along with lab technicians, have voiced concerns about their poor condition and shortage of materials and equipment.

Rawaa also explained that in grade 12, teachers strictly follow a predetermined syllabus, leaving little room for student input. This rigid curriculum minimizes student involvement. In the classroom, Rawaa only speaks when she feels confident about the discussed topic. Unfortunately, she faced additional challenges this semester, as she got in trouble with the teachers due to bad and experienced inconsistency in the school system when the chemistry teacher sent a violation throw this system to her father. This has caused trouble with her father, who confiscated her phone after a chemistry teacher complained about her. As the youngest student, Rawaa needs help participating effectively and earning respect in group projects and with teachers.

Rawaa also shared her difficulties with non-class subjects, particularly in religion. Being a non-Arab student, she feels overwhelmed by the abundance of information, especially in Islamic studies. Rawaa openly acknowledges her struggles in this subject and reveals that she received low scores on exams administered by the MOE.

4.16.9 Rawaa Relationship with Her Family

Rawaa reported that she had discussed the issues of bother and humiliation with her father. Her father was willing to arrange a meeting with the principal and her teachers, but Rawaa declined the offer. She didn't want to cause further stress to the teachers she might face again. Additionally, she didn't want to allow the teachers to claim, "Dad had to handle the situation because I couldn't handle it myself" (Rawaa, personal communication, May 13th, 2023). Rawaa mentioned that she gathered the courage to approach her teachers and emphasized, "I am a student at this school, just like everyone else. I deserve to be treated with respect and not be humiliated" (Rawaa, personal communication, May 13th, 2023).

During the discussion about her father's involvement, Rawaa expressed that her family plays a significant role in her education. They want her to focus solely on school and not work. Her older sister has a strong influence on her and is concerned about her well-being, both mentally and physically. Regarding school support, Rawaa remarked, *"Teachers will be teachers, some are good, and some are bad... Teachers should be passionate about what they are teaching. If they lack passion, they can't share it positively with others. Teachers should display more compassion and interest in the students they work with" (Rawaa, personal communication, May 13th, 2023).*

When asked about her progress over the past year, Rawaa mentioned that she had gained independence in her learning and how she approached education. If she isn't interested in her classes, staying engaged and keeping up with assignments becomes challenging. Dealing with mistreatment, she has learned to stand up for herself early on and prevent the situation from escalating. Rawaa concluded the conversation with a couple of additional comments. She expressed her interest in possibly returning home to continue her studies in the United States. She misses her home, her mother, and her extended family. Rawaa believes that she has the right to choose her path without the pressure and expectations imposed by her father, as she will soon turn 18 and is in America. She wants to exercise her right to decide her future and major without any interference or stress from her father. She closed by saying,

" It is challenging to fit into a school or a college or major in future if you don't match the norm, she concluded. If you don't 'Cowboy Up,' you don't receive a lot of support at this school, according to (Rawaa in a personal communication on May 13, 2023."

She giggled when I asked her about "*Cowboy Up," "you know cowboy boots, snug jeans, button-down shirts, and either a cap not turned backwards or a cowboy hat." I then pleaded with her, "Rawaa."* Could you please elaborate further?

As for the phrase "Cowboy Up," Rawaa explained that it refers to a cultural expression associated with cowboys and influenced by the American West. It signifies being tough, resilient, and determined to face challenges. "Cowboy Up" encourages individuals to stay strong, persevere, and confront difficulties with bravery and a positive mindset, similar to how cowboys face the demanding lifestyle of the Old West. It emphasizes tackling obstacles head-on, displaying unwavering strength, and maintaining a determined spirit (Rawaa, personal communication, May 13, 2023)

4.16.10 Notes of Discovery for Rawaa

Rawaa, a student in grade 8 in the United States, faced the challenge of juggling two difficult subjects, English and Chemistry, at the college level. However, adjustments had to be made to ensure she could complete her grade 12 academic year. Moving to a new country with her family gave Rawaa a sense of security, alleviating concerns about

basic needs like food. Her family, especially her supportive father, provided her with the financial means to have everything she needed and more, even attending an expensive school in Alain. Despite most students in her school coming from affluent backgrounds, Rawaa never felt inferior; she often found herself having more than her peers.

Nevertheless, Rawaa encountered difficulties with some teachers who treated her with humiliation. Although she never sought school resources or services to guide her rights within the grade 12 academic year, her stress and frustration were evident. She received advice from different teachers, each with an agenda and approach. The teachers should cooperate with Rawaa, which includes the prerequisites for grade 12, and give her the necessary advice. To illustrate, registration for a Chemistry class necessitated the mathematics competency at a minimum level, which she had not fulfilled before. Nowadays, Rawaa's intelligence and cheerful disposition, along with a sufficient measure of guidance, advice, and assistance from her school, teachers, and fellow family members, can definitely make her a fruitful student and enable her to enjoy her grade 12 completely.

This chapter gives the data collected from the interviews conducted with 8 grade 12 students as part of the research project on the OQA of chemistry students in the UAE. This study applied methods such as observation and recording of students' work, teachers' interactions, and non-verbal cues. The subjects were the students of an American school in Al Ain that I selected on the basis of my familiarity with this school as a former head of the department for ten years. Besides that, school systems, lab records, student work, and teacher plans were reexamined. The aim of the interviews was to explore the challenges students meet in grasping organic quantitative analysis, one of the most important topics in chemistry course.

The motive for organizing these interviews was to get a clearer perception of the complications grade 12 students may have to face in their last high school years of education. Reflective observations and documentation captured personal thoughts, experiences, and unspoken reactions to the interview questions. A triangulation approach was employed to analyze the data, utilizing three methods:

I. Observation of the eight student participants

II. One focused interview with a unique student case study telling her story and interview with 8 students

III. Review of teacher and student documents

Through repeated readings and content analysis, 15 nodes and three emergent themes were identified. The nodes were automatically gathered and organized into a hierarchical structure for in-depth analytical coding aligned with the research questions. The final structure and scaffold of the hierarchical layout for all nodes were generated.

Apart from the interviews with students, additional information was gathered from two chemistry teachers in an informal setting, treating them as colleagues and friends rather than following a formal interview format. The interviews with students were transcribed, and the data was analyzed using NVIVO12 software to identify patterns and themes.

Chapter 5: Conclusion and Implications

5.1 Overview

Progressive academic success within the subject chemistry mandates an understanding of macroscopic, microscopic and symbolic phases, with an emphasis on the various difficulties faced by the students, in transitioning between these representations (Gabel, 1993; Gabel, 1998). Chemistry is deemed integral for both students, and the general public, driving a comprehensive understanding of science and addressing the environmental issues (Hassan, 2017). As the Emirati students have been illustrating low performances in the international assessments such as TIMSS, and PISA, there is an immediate need to investigate the factors impacting the chemistry learning (Ridge et al., 2017; Nja et al., 2019).

The qualitative analysis of the organic compounds/substances within the chemistry curriculum has been explored with an emphasis on the essential functional groups and techniques such as Bromine Test and Baeyer's Test (Buthelezi et al., 2020; Atkins & Beran 1992; Fieser & Williamson, 1992). The difficulty Emirati students face in identifying functional groups and the need for improvements in teaching methodologies are highlighted (Adu-Gyamfi et al., 2017; Anim-Eduful & Adu-Gyamfi, 2022).

5.2 Analysis of Findings

In light of the findings, several critical themes emerged that shed light on the multifaceted landscape of learning OQA in chemistry. The themes identified comprised critical aspects of teaching and learning which led to comprehensive understanding of the dynamics and challenges within the educational context. The importance of teaching resources as highlighted by Duffy & Cunningham (1996), devises a foundational theme, placing emphasis on the critical role of tangible resources/elements such as reagents and laboratory equipment.

Practical based instruction surfaces as another critical theme, drawing focus to participatory pedagogical approaches such as PjBl, and Olabs, as discussed by Ratamun, (2018) and Nedungadi et al. (2015). Furthermore, the evaluation of organic chemistry curriculum content, challenges faced by the teachers, absence of adequate resources, and

issues in instructional methodologies; this collectively contribute to a nuanced investigation of the educational landscape, aligned with the current literature and scholarly perspectives (Gabel, 1998; Carey, 2000; Russell & Weaver, 2011).

In the following passages, I will highlight each of these emerged themes and discuss how each of these themes shape students' learning of OQA in chemistry.

5.2.1 Teaching and Learning Resources and Teaching Challenges

Reagents, the laboratory space, and equipment for effective practical based OQA teaching is immensely significant – According to the Resource based Learning Theory, the role of tangible resources is critical in developing relevant knowledge and improving learning outcomes (Duffy & Cunningham, 1996). According to Ratamun, and Osman, (2018) practical work fosters scientific attitude among chemistry students, contributing to improved problem-solving competencies. Laboratory activities play integral role in cultivating interest altering attitudes and supplementing to effective chemistry teaching. Furthermore, virtual labs are immensely effective as compared to physical labs.

The study conducted by Hsiung (2018) revealed that students overall academic performance in chemistry improved due to Moodle e-learning platform where the learners could access the digital resources at any time. When chemistry instructions were integrated with augmented reality, and simulations, the students found digitalized resources highly beneficial – it led to improved ability to answer questions, and grasp in-depth knowledge about several chemistry concepts. The outcomes of the research indicated a positive impact on the student's chemistry learning through incorporation of e-resources. Digitalizing Chemistry education seems to offer a workable solution for the insufficient materials, and chemicals in the laboratory, that participants in this study mentioned.

The misalignment between the devised objectives within the lesson plan and the actual implementation by the instructors reveals a critical challenge in delivering practical lessons. The discrepancies identified between the planned and executed units are not uncommon within the educational settings (Leinhardt, 1998). The chemistry teachers may deviate from the lesson/unit plans because of several issues such as time constraints, resource limitations, or unforeseen challenges within the classroom.

In such regard, the issues faced by the chemistry instructors, such as the large class sizes, and unavailability of the academic resources, resonate with the previous researches on the impact of the materials constraints of practical lessons, limiting the student's ability to understand conceptually which present significant obstacles to students' understanding of OQA (Carey, 2000). Concepts are developed through experiences, which involve the construction of complicated representational structures (Carey, 2000).

As per Lee and Takahashi (2011), lesson plans are integral instruction tools, which dictate and order the teaching sequence. Yet discrepancies often exist between the planned and actual class outcomes. This prompts inquiries in the issue of how teachers adapt to uncertain situations during real-time interactions and incorporate lesson plans adequately. Lesson plans typically lack precise details regarding the actions and choices teachers and students make during the real-time classroom conversations. Hence it is critical to analyse the teaching practices within a particular variating context of the classroom settings, as highlighted by Cochran-Smith and Zeichner, (2009); teacher educational programs should be examined in such a way that it identifies their complexities, connections, and dynamics to the individuals involved and environment (Cochran-Smith & Zeichner, 2009).

The lack of mandatory academic resources leads to potential barriers towards the conceptualization of OQA by the students. This resonates with the Socio-cultural Theory, placing emphasis on the role of culturally based tools and artefacts usage within the cognitive development as guided by Vygotsky, (1978). The absence of up-to-date and extensive resources limits students' ability to bridge the gap between theoretical understanding and real-life applications of the chemistry concepts.

The absence of resources significantly limits the student's abilities to comprehend OQA within chemistry. The study of organic compounds and their relevant chemical reactions, is immensely critical towards understanding of Organic Chemistry, which mandates an in-depth analysis of functional groups and complicated theories (Hanson, 2017). However as per analysis of Katsampoxaki-Hodgetts et al. (2015) lack of academic resources hinders student' access to practical experiments which challenges to close the gap between theoretical knowledge and real-world applications.

Such conditions lead to students struggling with visualizing the microscopic

concepts such as atoms, molecules, chemical bonds, and reactions impeding their understanding of OQA (Akaygun et al., 2014). This challenges to intensify when students attempt to categorize the organic compounds based upon their properties due to deficiency in conceptual understanding (Akkuzu & Uyulgan, 2016). Furthermore, the shortage of resources also impacts the teaching methodologies, which ultimately dominates the traditional lecture-based approaches, placing focus on imparting the scientific terminologies rather than fostering the critical thinking competencies (Concannon & Brown, 2008).

Inappropriate laboratory facilities and equipment also hinders the effectiveness of the practical experiments, integral for improving problem solving competencies and conceptual understanding of concepts (Kurbanoğlu & Akim, 2010). Such limitation is exacerbated by the student's reliance on memorization of formulas rather than developing an in-depth comprehension of Organic Chemistry (Anim-Eduful & Adu-Gyamfi, 2022; Bhattacharyya & Bodner, 2005). In a nutshell, the scarcity of resources leads to several challenges towards meaningful learning experiences in Organic Chemistry, limiting the intellectualization of the reaction mechanisms, and overall hindering the grasp of OQA (Talanquer, 2018).

Building models supplement students in comprehending of associations and differentiations among different science concepts, particularly in chemistry's submicroschopic, macroscopic and symbolic representations (Wu et al., 2001). Attaining knowledge and learning at these levels is integral for improved comprehension and application of the chemistry concepts (Gabel, 1998; Johnstone, 1993; Sanger, Phelps, & Fienhold, 2000).

As highlighted by Carey (2000), and Wu et al. (2001), the impact of material/resources constraints on practical lessons underscores the significance of well-equipped laboratories, including virtual labs, and available resources for effective learning. Furthermore, the student's attitudes towards science, an integral factor within learning are fostered through teaching methodologies (Hacieminoglu, 2016); as per Hassan et al., (2017) negative attitudes can hinder the academic performances of the students.

According to Katsampoxaki-Hodgetts et al. (2015), science laboratory techniques are immensely integral for understanding the scientific concepts are hindered by the challenges related to ineffective teaching strategies and inadequate resources. The importance of overcoming the discussed challenges is evident in the call for inquiry based or cooperative learning approaches as discussed by Concannon and Brown, (2008) to improve student learning and achievement within OQA.

The findings of Vermaat et al. (2003), revealed that groups of chemistry students were able to develop animations which led to a strong learning effect. Students were able to give explanation of why solid salt and distilled water are insulators however the salt solution is able to conduct electricity. The students were also able to replicate scientific accepted models. Teplá et al. (2022), outcomes revealed that almost 565 science students who utilized 3D models and animations elevated the intrinsic motivation of the students for leaning natural science subjects. The most positive effect was evident in Chemistry (g=0.74). Similarly, Wu et al., (2001) found that through the utilization of computer-based visualization tool, the students became proficient in understanding symbolic and molecular representations.

5.2.2 Practical-Based Instruction and Student Perspectives

The practical based instruction places emphasis on the utilization of the participatory driven pedagogical approaches to improve the students learning of the chemical related concepts. This is aligned with Constructivist theories that argue for active engagement and hands on experience in the knowledge attaining process (Piaget, 1973; Vygotsky, 1978). The challenges associated with the limited laboratory space and insufficient materials/resources hinder the adoption of the practical based instruction, influencing the students conceptual understanding.

For instance, Van Brederode et al., (2022) found a significant impact of pre-laboratory activity design on the student's conceptual understanding during the inquiry tasks. Chemistry students engaging in conceptual understanding of the pre-laboratory activities also illustrated elevated levels of motivations for in-depth contemplation of the measurement meanings as compared to those students who involved in conventional or limited pre-laboratory activities.

The paper published by Nedungadi et al. (2015), proposed an innovative pedagogical methodology for chemistry practical experiments which facilitated the practical based instruction, utilizing three modes of inquiry-based learning: a) open, b) guided, and c) structured. For this purpose, OLabs, (Online Labs) were proved to be effective as they offered animations, assessments, simulations, tutorials, fostering student-centered learning, evidence-based reasoning, scientific thinking, and creative problem-solving competencies for knowledge development and improved recall.

The study conducted by Ifepe, and Anekwe, (2022) found that due to limited laboratory space, students had poor practical chemistry knowledge related to identification of atoms, molecules and ions, and acid-base titration experiment. Recommendations were made to elevate the exposure of the students to experimental work. Due to its ease of usage, cost-effectiveness, efficiency, safety measures and promotion of scientific literacy, the implementation of microscale experiments are advised for the chemistry teachers to improve the practical lessons.

The student-based perspectives on the issues of acquiring knowledge regarding OQA with the absence of practical based instruction aligns with the educational theories, placing emphasis on the hands-on experiences within the learning process. Moreover, the desire of the students for visible, and practical lessons corresponds with the constructivist learning theories, suggesting that learners actively build their understanding through direct experiences (Piaget, 1952).

Direct experiences play integral role within improving student's learning in scientific concepts through fostering an-in-depth understanding and facilitation of skills development (Sofoklis et al., 2017). As per Shana and Abulibdeh, (2020), practical work within science education aligns with the objectives of enhancing the students understanding, problem- solving competencies and appreciation for the nature of science. Sharpe & Abrahams (2020) places emphasis on practical work offers direct experiences which encourages real life application of theories, and accurate observations.

5.2.3 Organic Chemistry Curriculum Content and Conceptualization Challenges

This theme looks forward to evaluate and explore how the instructors and students

perceive the content of OQA within the curriculum. The Curriculum Alignment Theory places emphasis on merging the curriculum content with instructional practices (Fullan, 2007) – the discrepancies between the curriculum content and the actual availability of the academic resources creates barriers towards effective alignment of all components, negatively influencing the student's comprehension.

The previous literature by Gabel (1998), and Smith and Scharmann, (2008) supports the idea that hands on experiences, proper academic resources, availability of the resources, and mergence with the curriculum objectives positively influence the student's understanding of the concepts related to chemistry subject. Moreover, the research also aligns with the wider literature on the resource constraints within the Science education (Bencze et al., 2002; Hodson, 1996).

Researches such as Moe (2011) and Akkuzu and Uyulgan (2016) places emphasis on well-developed teaching programs and activity-based teachings in order to improve the understanding of chemistry students of scientific theories and promote alternative perceptions. Addressing of these multi-facet attributes, contributes to more effective and resourceful chemistry education (Abarro et al., 2021; Hassan et al., 2017).

The discussion around the timing of teaching OQA and the perceived difficulties in conceptualizing the subject aligns with curriculum design theories. The teachers' acknowledgment of the extensive and abstract nature of OQA supports the need for careful consideration of curriculum content and sequencing . Students' differing views on when OQA should be taught underscore the importance of considering diverse learner needs and preferences (Vygotsky, 1978). The suggestion for an early introduction to OQA corresponds with research advocating for a spiral curriculum, where complex topics are revisited and deepened over time .

The early introduction of OQA is immensely integral based upon the findings of Adu-Gyamfi et al. (2017), which revealed significant challenges faced by the SHS (Senior High School) chemistry students; students faced difficulties with identification of the functional groups, IUPAC naming of the organic compounds, and determining the correct position and identification of multiple bonds within the organic molecules. Reports were published by Western African Examinations which were based upon almost two decades,

2001 to 2018; the reports highlighted several challenges faced by the SHS chemistry students in QOA classes, both in theoretical, numerical and practical assessments (Anim-Eduful & Adu Gyamfi, 2018).

On the other hand, the study conducted by Tan on 10th grade chemistry students revealed several challenges in context to understanding different concepts related to OQA in both pursuits, theoretical and experiments (Anim-Eduful, 2020). Hence, in light of the analysis conducted by Anim-Eduful, and du-Gyamfi, (2022) it is imperative to introduce OQA within the curriculum on earlier basis – such an initiative will address such challenges through offering students with foundational knowledge and skills critical for advanced understanding, paving academic performance within both practical applications and academic assessments.

5.2.4 Issues in Instructional Methods Usage in the Classroom

The concerns within the instructional methodologies utilization within the classrooms underscores the need of effective teaching approaches to facilitate the OQA conceptualization by the students. In line of the Constructivist theory, it places emphasis on the active engagement and interaction of the instructional methods (Dewey, 1916). The research sheds light on the current instructional methodologies which lack practical based approaches, and contribute to the student's challenges/struggles in the understanding of the OQA.

Previous research such as Russell and Weaver (2011), supports the notion of practical based approaches, as they improve the student's understanding different scientific concepts. According to Russell and Weaver (2011), the relationship between the instructional methods is evident in the impact of laboratory curriculum on the chemistry students in context to theories and conceptions. It has proved to be most effective, resulting in significant gains for the students as compared to traditional and inquiry-based laboratories.

The research also aligns with the previous studies shedding light on the challenges of resource inadequacy within the science education (Abd-El-Khalick & Lederman, 2000; Zeidler, 2002). As per Abd-El-Khalick and Lederman, (2000) there is a critical need for

fostering reforms within science teacher education, placing emphasis on the significance of cultivating nuanced perspectives of nature of science (NOS) among prospective teachers.

To better support the students, schools should incorporate explicit instructions on NOS within teacher educational programs, integrating the elements from philosophy of science (Abd-El-Khalick, & Lederman, 2023). Integrating the NOS discussions within curriculum design, micro-teaching, and evaluation courses offers practical avenue for reflection, ensuring that prospective teachers incorporate NOS seamlessly within classroom practices (Abd-El-Khalick & Lederman, 2000).

The language challenges faced by students, as expressed in their difficulty in understanding instructional material delivered in English, align with the literature on language-rich learning environments (Cummins, 1981). The students' preference for explanations in their native language reflects the importance of considering language diversity in instructional practices (García, 2009). The use of visuals, models, and animations suggested by students corresponds with multimedia learning theories, emphasizing the effectiveness of visual aids in enhancing comprehension (Mayer & Moreno, 2003). The incorporation of these elements can address language challenges and facilitate a deeper understanding of complex concepts.

According to Fan (2010), foreign background students in university context encounter ‘language shocks’ stemming from the differences evident in language systems, impressions and attitudes. These shocks variate in stages, and intensity, affecting emotions and learning. Students struggle on linguistic basis with phenomena absent or/and distinctive in their native languages such as tenses, plural nouns, pronunciation, articles and prepositions. Socio-linguistically, students grapple with different cultural nuances within criticisms, feedback, compliments, greetings, and appellations. These challenges are aligned with the researches conducted by James (1980) and Chesterman (1998), indicating interferences from their first languages. Language discrepancies impact both linguistic and socio-linguistic perspectives of communications, hindering the student’s comprehension and integration within the university environment.

5.2.5 Unmotivated Teacher and Teacher Professional Development

The instructors/teachers are facing variating challenges not limited to lack of motivation, frustration and other negative feelings which sheds light on the immediate need for continual professional development. The teachers' efforts to adapt their teaching methods in the face of resource limitations demonstrate resilience, but sustained motivation requires systemic support and recognition (Hargreaves & Fullan, 2012).

The teacher's suggestion for workshops, technology integration, and collaboration among teachers echoes the literature on effective professional development practices Ongoing training, collaborative initiatives, and mentorship programs can contribute to teacher motivation and effectiveness (Darling-Hammond et al., 2009). Moreover, Hofstein, (2005) conducted study on chemistry teacher's training and development program which revealed improving the teacher's comprehension of current trends within chemistry education, comprising of both substance and instructional approaches of chemistry learning and teacher were a crucial segment.

Copriady, Zulnaidi, and Alimin, (2018) explains the significance of continuous training for improving the quality of chemistry education among the teachers, placing emphasis on the development of Academic Online Community; the trainings lead to teachers embracing a mindset that aims to provide valuable experiences, employing effective methodologies like conducting laboratory experiments, to facilitate mastery of chemistry. Furthermore, the progression of school, and caliber of knowledge with experience is imparted to the students depending on the teachers (Copriady, Zulnaidi, & Alimin, 2018).

According to Chu et al. (2015), teacher's expertise directly impacts the student achievement, and innovative teaching approaches improve instructional quality . Othman (2009) shed light on the positive effects of technology assisted teaching on the student achievement, aligning with the perspective of Rahman et al. (2011) that training and development of the teachers lead to improvements within competencies, knowledge and student learning. Hence, overall, the training and development of the chemistry teachers positively impact the academic progress of the students.

5.2.6 Support for 12th Grade Students

The discussion on the support needed for 12th grade students emphasizes the importance of teacher autonomy and flexibility in adapting to students' needs (Deci et al., 1991). Teachers require support in terms of resources, training, and collaborative opportunities to enhance their instructional practices and better meet students' learning needs. The emphasis on using real-life examples and creating a language-rich learning environment aligns with research on effective pedagogical strategies (Hattie, 2009). Providing ongoing training and establishing support teams within schools can contribute to a positive learning environment.

5.3 Themes Emerged from Rawaa's Case Study

In this critical discussion, the research delves into the case study of Rawaa, exploring various aspects of her educational journey and shedding light on the challenges she faces in the context of learning OQA in chemistry. The analysis will be grounded in the existing literature on factors influencing students' academic performance and experiences, particularly in science subjects.

Rawaa's journey begins with her transition from an elite high school in Texas to an American school in the UAE during her 12th grade year. Her background, marked by financial struggles, family dynamics, and the relocation to the Middle East, adds a layer of complexity to her academic experiences. According to Napolitano et al. (2013), with the near-globalized aspiration for college education, the expenses are linked with attaining college degrees which has escalated significantly. Over the past three decades, the college tuition fee has also increased two times due to inflation.

These factors, as highlighted by scholars (Bourdieu, 1977; Lareau, 2015), can significantly impact a student's engagement and performance in school. The theory of Pierre Bourdieu related to education is interlinked with class inequalities in educational attainment; it is further related to class reproduction within a capitalist community. Furthermore, Lareau (2015), explains that educational achievements are also impacted by the class positions of the parents. Young students also tend to miss deadlines of their academic assessments, or either pick a career path which is not favorable for them.

Several themes have been identified for the case of Rawaa; the student's background, marked by financial struggles, family dynamics and relocation results in complexity to her academic experiences. Rawaa's language proficiency, particularly within Arabic, emerges as a crucial constitute in impacting the learning experiences. The themes place emphasis on the role of effective classroom communications which aligns with the findings of teacher-student coordination researches. The inadequacy of the support systems within the school, evident by academic-resource limitations, and rigid curriculum, increases Rawaa's difficulties. Furthermore, the cultural background of Rawaa sheds light on the issues of cultural adaptation and its impact on academic performance. Also, the assertation of autonomy is critical as it increases the motivation of the students.

5.3.1 Language Proficiency and Academic Performance

Rawaa's language proficiency, particularly in Arabic, emerges as a critical factor influencing her learning experience. The literature review supports this observation, emphasizing the role of language in science education (Alieto, 2018; Beka, 2016). Rawaa's struggles with her chemistry teacher, who predominantly uses Arabic, underscore the importance of effective communication in the classroom. Moreover, Rawaa's plea for the teacher to explain in English, her preferred language, and the subsequent negative response from the teacher align with studies on teacher-student communication and its impact on student engagement and motivation (Wentzel, 2002; Pianta et al., 2003).

According to Varga, (2017), previous researches have reported positive association between instructors and learners which serve as a critical predictor of academic progression and engagement. In developing a conducive learning environment positive relationship between teachers and students emerge as a potent medium. Students who perceive greater support from their teachers, tend to attain improved academic outcomes.

According to Van der Merwe, (2018), the academic success of the students is widely dependent upon their academic writing and reading competencies. Hence, for the teachers it is mandatory to teach the academic language on explicit basis and intentionally. For the academic progression of the students, the teachers should constitute of the knowledge of academic language and its attributes.

Consequently, teacher education students should receive explicit instruction on academic language, coupled with ample opportunities to enhance their proficiency in its usage (Vander Merwe, 2018). As investigated by Beka (2016), and Alieto (2018)., the impact of language competencies on understanding becomes significantly relevant within the Emirati context, where diversified linguistic backgrounds may influence the student's science concepts development.

5.3.2 Teacher-Student Dynamics and Support Systems

The dynamics between Rawaa and her teachers play a pivotal role in shaping her academic experience. The challenges she faces with her chemistry teacher, including feelings of humiliation and a lack of understanding regarding her unique needs, resonate with the broader literature on teacher-student relationships (Roorda et al., 2011; Hughes et al., 2012). According to Roorda et al. (2011), significant attention has been given to the topic of TSRs, affective teacher student relationships as to facilitate the students to be adjusted within schools. The quality of the TSRs is positively correlated with reducing student's behavioral problems, elevating social functioning, academic achievement, and higher engagement within learning activities.

Similarly, Hughes et al. (2012) cites several longitudinal researches which report teachers who create a supportive relationship with their learners, pose a positive impact on the academic and behavioral pursuits. The absence of adequate support systems within the school, as evidenced by the inadequate resources in the labs and the rigidity of the curriculum, further compounds Rawaa's difficulties. This aligns with studies emphasizing the significance of supportive environments for student success (Deci et al., 1991; Eccles & Roeser, 2015).

As per analysis of Deci et al. (1991), teachers fostering autonomy among students leads to comprehension of student's cognitive standpoint and elevates motivation. The recommended support for self-determination comprises of teachers offering students with choices, minimizing the constraints, validating their academic pursuits and emotions, and providing them necessary knowledge for task execution. Similarly, Eccles and Roeser, (2015), explains regarding schools being intricated multi-level entities that impact the social-emotional, academic and behavioral development of the students through

diversified mechanisms. In such context, teachers direct affect student achievement linked to motivation, and instructional quality.

According to Boesdorfer (2019), chemistry educators across different educational levels plays critical role in shaping the future of the students, who may look forward to pursue careers as STEM professionals, chemical engineers, and chemists. The inclusivity and effectiveness of their teaching substantially impact the student's interests and success in chemistry. However, teaching chemistry is a multi-faceted process that mandates an in-depth understanding of the chemistry content, student dynamics, assessment approaches, and instructional methodologies.

Boesdorfer (2019) also explained that just as these teachers develop opportunities for the students to improve their comprehension for chemistry, they also require avenues for refining their pedagogical competencies. Provided the continual reforms within the chemistry education and rapid demand for qualified chemistry professors and teachers within K-12 settings, customized learning experiences that positively influence teaching practices are imperative for the chemistry educators at all academic levels.

5.3.3 Cultural and Contextual Challenges

Rawaa's cultural background, coupled with the challenges of being a transfer student, adds another layer to her story. The notion of 'Cowboy Up' that Rawaa introduces reflects her attempt to navigate the cultural nuances of her current educational environment. Cultural adaptation and its impact on academic performance have been explored in various studies (Ward & Kennedy, 1993; Berry, 2006), and Rawaa's experience contributes to this discourse. According to Ward & Kennedy (2006) indicates factors such as language proficiency, cultural distance, cultural separation, satisfaction with host national interactions, and mood disturbances contribute to cultural and contextual challenges, explaining a 52 percent of variance in socio-cultural adaptation.

Similarly, Berry (2006), explains that foreign students face different challenges, dilemmatic situations, and opportunities which bring changes within their lives and welfare. The findings of Ward and Kennedy (2006) compared with the home-based students in the New Zealand, shed lights on the abroad residing students to face much more socio-cultural challenges. Similarly, the study conducted by Fook and Sidhu (2015)

revealed that international students face significant cultural challenges when they study in USA – the challenges which hindered their academic journey included, difficulty in understanding important topics which are unique to American culture.

Students were also hindered by issues related to assimilating with the local culture, and misalignment with the active classroom culture. According to Fook and Sidhu (2015) in home countries of the students, the classroom dynamics differentiate with teachers taking a dominant roles and students are passive learners. Such cultural differences result in reluctances among the foreign students to take part in classroom discussions pro-actively. This signifies the importance of addressing cultural and contextual factors to improve the overall academic journey of the student.

Fook and Sidhu (2015) contends that addressing these cultural differences via cultural orientation programs and sensitivity training for the teachers can facilitate to develop a more inclusive learning environment for international students. As per Kutsyuruba et al. (2017), the acknowledgement and respecting students' cultural backgrounds, offering opportunities to share their experiences and encouraging open dialogue regarding cultural differences is important to mitigate cultural challenges. Moreover, teachers who adapt to instructional strategies accommodating versatile learning preferences enable an inclusive and supportive classroom environment where students feel values; they have a sense of belongness and improve academic outcomes as well.

5.3.4 Student Autonomy and Motivation

Rawaa's assertion of her right to decide her future path and major without interference aligns with literature highlighting the importance of student autonomy and motivation in academic success (Deci et al., 1991; Pintrich, 2003). The intersection of personal interest, motivation, and external expectations emerges as a complex interplay influencing Rawaa's decisions and experiences. The findings of Kraan (2023) revealed preferences for elevated autonomy in defining the learning outcomes/objectives for the students and integrating more diversity within the lessons and curriculum. The autonomy of the students led to structured instructions, demonstrations and individualized support. The importance of a positive teacher student association emerged as a critical factor for supporting student's autonomy.

As per González, & Paoloni (2015) the interactions between teachers and students within the classrooms, impacts the success rate of their academic progression; several components of Self-Determination Theory (SDT) have outlines particular classroom interactions such as perceived autonomy support. To further support the notion, Vaino et al. (2012), explains the theory of SD promotes sense of autonomy, competences, relatedness on individual basis which are believed to encourage students to become most self-directed and have elevated levels of motivation.

Similarly, the research conducted by Johansen, Eliassen, and Jeno (2023) revealed that as per Self-Determination theory, support for student autonomy is necessary for proper functioning of the students and fostering optimal learning across all educational levels. autonomy support from the teacher to the students has been a direct and indirect contribute to academic progression. The findings of the study conducted by Osma et al. (2015), revealed reasons and determinants negatively impacting the chemistry student's motivation, including ineffective university orientation, pedagogical approaches, lack of teacher's vocation and lack of communications.

According to Davis and Bowles (2018) teachers motivate their students through driving intrinsic motivations via purpose, mastery and autonomy. Offering choices in assignments and permitting students to pursue topics of personal interest promotes autonomy; while offering constructive feedback and opportunities for improving mastery. Furthermore, connecting to classroom activities to the real – world applications integrates a sense of purpose. Integrating collaborative learning experiences and multimedia resources further engages students. Furthermore, there is a need of acknowledging student's achievements and efforts to boost their confidences. Through the development of a stimulating learning environment, teachers can inspire their students to become active and progress academically (Davis, & Bowles, 2018).

5.4 Limitations of the Study

While this study sheds light on student experiences with OQA learning in the UAE, it acknowledges limitations. Firstly, the research focuses on a single international school in Al Ain. This limits the generalizability of findings to the broader UAE educational landscape with its diverse range of schools and curricula. Secondly, the study relies on

student self-reported experiences through interviews and observations. While valuable, this approach can introduce bias as students may not always accurately reflect on their learning or challenges. Finally, the chosen qualitative methods, while insightful, don't directly assess students' actual understanding of OQA concepts. This limits the ability to measure the effectiveness of teaching approaches or identify specific knowledge gaps.

5.5 Chapter Summary

In conclusion, the discussion elucidates the factors influencing students' understanding of OQA and the challenges they face in the UAE educational context. The findings underscore the importance of adequate resources, practical-based instruction, and alignment with curriculum goals for effective teaching and learning. The study contributes valuable insights for educators, curriculum developers, and policymakers to enhance the quality of chemistry education in the UAE, with implications for broader science education globally. However, addressing the identified challenges will require concerted efforts in resource allocation, teacher professional development, and curriculum reform.

Table 1: Research Questions and Findings on Factors Influencing UAE Students' Understanding of OQA

Research Question	Findings
I. What factors influence 12th grade UAE students' understanding of OQA?	* Teaching and Learning Resources & Teaching Challenges * Insufficient reagents, laboratory space, and equipment hinder practical OQA learning. * Misalignment between lesson plans and actual implementation limits student understanding. * Large class sizes and lack of resources limit student understanding. * Practical-Based Instruction and Student Perspectives * Limited practical instruction due to resource constraints. * Importance of practical experiences for student understanding (aligned with Constructivism).
II. What are the challenges that 12th grade students face in conceptualizing OQA and how to overcome these challenges?	* OrganicChemistryCurriculum Content and Conceptualization Challenges * Curriculum content and resource availability may not be aligned. * Difficulties with abstract and extensive OQA content. * Issues in Instructional Methods Usage in the Classroom * Current methods lack practical approaches, hindering OQA understanding (aligned with Constructivism). * Language challenges for students with English instruction. * Unmotivated Teacher and Teacher Professional Development * Teachers face challenges including lack of motivation and need for professional development.
III. What sort of support do 12th grade students need to better understand OQA?	* Practical-Based Instruction and Student Perspectives * Students value practical experiences for understanding OQA. * Issues in Instructional Methods Usage in the Classroom * Students benefit from instruction in their native language and the use of visuals and models. * Support for 12th Grade Students * Teachers need support with resources, training, and collaboration to improve instruction and meet student needs.

For addressing the identified challenges, the instructors/educators should deploy dynamic strategies such as using vocabulary cards, diagrams, illustrations, virtual labs, and encouraging simple hands on procedures within the classroom. These approaches are aligned with the Cognitive Load Theory, which indicates that presenting information in multiple forms/formats and engaging the students in activities minimizes the cognitive burden and improves learning (Sweller, 1988). Previous and latest researches, such as Mayer and Moreno (2003) and Clark and Mayer (2023), supported the utilization and hands on related activities to improve the overall learning outcomes.

For overcoming the challenges within chemistry learning align strategies with research-based insights from cognitive sciences. As per the analysis of Mayer & Moreno (2003), principles such as cognitive capacity, dual channel processing and active

engagement should be utilized. It is critical to implement multimedia methods for reducing cognitive load for effective learning. What Clark & Mayer (2023) explains regarding designing and consuming multimedia learning materials, chemistry students can exploit opportunities through optimized instructional strategies – students and teachers both can attain several benefits from utilizing various multimedia forms, fostering improved comprehension and knowledge retention.

The research is aligned with the literature placing emphasis on the significance of distinctive instructional strategies for accommodating diversified learning mandates (Tomlinson, 1999). Hofstein (2004) explains instructional strategies, specifically involving laboratory activities which are invaluable for both chemistry teachers and students. Laboratories provide an effective medium to attain science educational objectives by supplementing the students in developing knowledge, constructing inquiry-based skills, and improving problem solving capabilities.

According to Zhao (2023), being an experimental sciences subject, chemistry lacks experimental training among middle and high schools commonly. In many developed countries, chemistry labs equipment is replaced by computer simulations, where chemistry students fail to grasp the topic deeply. To address such issues, equipment such as electron microscopes, Raman spectrometers, X-ray diffractometers, and mass spectrometers should be allotted by the Ministry of Education (Zhao, 2023). The recommendations proposed by Stojanovska et al. (2020), revolve around ensuring ongoing improvement process within chemistry education; it is critical to improve curricula, enhance working environments, provide needed equipment for experiments, teaching materials and other academic resources.

Stojanovska et al. (2020), also proposed financial support should be boosted for maintaining school equipment and facilities. Teaching quality depends upon the availability and access to lab materials and resources, that are critical for students to acquire comprehensive knowledge. Allocation of an annual budget for the teaching resources in natural sciences subjects is imperative along making the labs advance by equipping it with latest chemistry experimentation equipment. Ineffective fund allocations often leave the schools with absence of sufficient resources to fulfil the basic needs of the

students academically wise.

As quoted by Hanson, (2017), the research conducted by Bilgin and Geban proved the effectiveness of Context Based Learning which significantly improves the understanding of organic chemistry as compared to traditional teaching techniques. CBL uses real-world contexts with students' backgrounds, along with MCE, (Model Centric Engagement) to reinforce knowledge and enhance the application of chemistry concepts leading to positive attitudes of students. As quoted by Hanson, (2017), these propositions are supported by Fechner (2009) and Bilgin, Yurukel, and Yigit (2017) shedding light on increased interest of the students in chemistry subject. The study conducted by Broman and Parchmann (2014) also noted the effectiveness of CBL in fostering problem-solving competencies. Particularly in organic chemistry, active learning environments, facilitated by MCE and CBL, facilitate in developing mental models and coherent knowledge among the students (Hanson, 2017).

Future research may delve deeper into specific interventions and their impact on students' conceptual understanding of OQA. Hence, it can be concluded that addressing the identified challenges in teaching OQA requires a comprehensive and collaborative approach. This includes professional development for teachers, resource allocation, language support for students, and thoughtful curriculum design. Theoretical frameworks and insights from educational scholars can guide the development of interventions and strategies to enhance the teaching and learning of OQA in high school chemistry classes. Rawaa's journey provides valuable insights into the multifaceted nature of students' experiences in the academic realm. By critically examining her case in the context of existing literature, we gain a deeper understanding of the challenges she faces and the broader implications for educational practices.

References

Abarro, R. Q., & Asuncion, J. E. (2021). Metacognition in Chemistry Education. *Theoretical & Applied Science, 95*(03), 1-22. https://doi.org/10.15863/tas.2021.03.95.1

Abd-El-Khalick, F., & Lederman, N. G. (2000). Improving science teachers' conceptions of nature of science: a critical review of the literature. *International Journal of Science Education, 22*(7), 665-701. https://doi.org/10.1080/09500690050044044

Abd-El-Khalick, F., & Lederman, N. G. (2023). Research on teaching, learning, and assessment of nature of science. *Handbook of Research on Science Education*, 850-898.

Achor, E. E., & Ukwuru, J. (2014). An Examination of the facilitative effect of Computer Assisted Instruction (CAI) in Students' achievement in Chemical Reaction and Equilibrium. *Education, 4*(1), 7-11. http://dx.doi.org/10.2139/ssrn.2401088

Adu-Gyamfi, G., Song, H., Obuobi, B., Nketiah, E., Wang, H., & Cudjoe, D. (2022). Who will adopt? Investigating the adoption intention for battery swap technology for electric vehicles. *Renewable and Sustainable Energy Reviews, 156*, 111979. https://doi.org/10.1016/j.rser.2021.111979

Adu-Gyamfi, K., Ampiah, J. G., & Appiah, J. Y. (2017). Students' difficulties in IUPAC naming of organic compounds. *Journal of Science and Mathematics Education, 6*(2), 77-101.

Ajemba, H. E., Ahmed, F. M., Ogunode, N. J., & Olatunde-Aiyedun, T. G. (2021). Problems facing science teachers in public secondary schools in Nigeria and way forward. *International Journal of Discoveries and Innovations in Applied Sciences, 1*(5), 118-129. http://openaccessjournals.eu/index.php/ijdias/article/view/280

Akaygun, S., & Jones, L. L. (2014). How Does Level of Guidance Affect Understanding When Students Use a Dynamic Simulation of Liquid–Vapor Equilibrium? *Learning with Understanding in the Chemistry Classroom*, 243-263. https://doi.org/10.1007/978-94-

Akkuzu, N., & Uyulgan, M. A. (2016). An epistemological inquiry into organic chemistry education: exploration of undergraduate students' conceptual understanding of functional groups. *Chemistry Education Research and Practice, 17*(1), 36-57. https://doi.org/10.1039/c5rp00128e

Akram, T. M., Ijaz, A., & Ikram, H. (2017). Exploring the Factors Responsible for Declining Students' Interest in Chemistry. *International Journal of Information and Education Technology, 7*(2), 88-94. https://doi.org/10.18178/ijiet.2017.7.2.847

Alieto, E. (2018). Language shift from English to Mother Tongue: Exploring language attitude and willingness to teach among pre-service teachers. *TESOL International Journal, 13*(3), 134-146. https://www.researchgate.net/publication/330344045

AlMahdawi, M., Senghore, S., Ambrin, H., & Belbase, S. (2021). High School Students' Performance Indicators in Distance Learning in Chemistry during the COVID-19 Pandemic. *Education Sciences, 11*(11), 672. https://doi.org/10.3390/educsci11110672

Al Zarooni, E. B. (2014). *Impact of Guided Inquiry on Tenth Graders' Understanding of Chemical Bonds*. (Master thesis, United Arab Emirates University, United Arab Emirates). Retrieved 20 May 2023 from https://scholarworks.uaeu.ac.ae/cgi/viewcontent.cgi?article=1020&context=all_theses

Anim-Eduful, B. (2020). *Chemistry Teachers" and Students" Conceptual Understanding of Organic Qualitative Analysis* (Doctoral dissertation, University of Cape Coast). Retrieved 20 May 2023 from https://ir.ucc.edu.gh/xmlui/bitstream/handle/123456789/6814/ANIM-EDUFUL%2C%202020.pdf?sequence=1&isAllowed=y

Anim-Eduful, B., & Adu-Gyamfi, K. (2022). Chemistry students' conceptual understanding of organic qualitative analysis. *Pedagogical Research, 7*(4), em0132. https://doi.org/10.29333/pr/12307

Anim-Eduful, B., & Adu-Gyamfi, K. (2022). Factors Influencing High School Chemistry Teachers' and Students' Teaching and Learning of Organic Qualitative Analysis: A Qualitative Study. *European Journal of Education Studies, 9*(7),194-219. https://doi.org/10.46827/ejes.v9i7.4378

Anim-Eduful, B., & Adu-Gyamfi, K. (2021). Functional groups detection: Do chemistry teachers demonstrate conceptual difficulties in teaching. *Global Journal of Human-Social Science: G Linguistics & Education, 21*(7), 47-60. https://doi.org/10.34257/gjhssgvol21is7pg47

Apu, G. (2020). Factors Affecting Students Academic Achievement in Chemistry: A Case of Obudu Local Government Area. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3554319

Asghar, A., Huang, Y.-S., Elliott, K., & Skelling, Y. (2019). Exploring Secondary Students' Alternative Conceptions about Engineering Design Technology. *Education Sciences, 9*(1), 1-18. https://doi.org/10.3390/educsci9010045

Astalini, A., Kurniawan, D. A., Darmaji, D., & Anggraini, L. (2020). Comparison of students' attitudes in science subjects in urban and rural areas. *Journal of Educational Science and Technology (EST), 6*(2), 126-136. https://doi.org/10.26858/est.v6i2.12057

Atkins, P.W., & Beran, J. A. (1992). *General chemistry*. New York: ScientificAmerican Books.

Anim-Eduful, B., & Adu-Gyamfi, K. (2022). Chemistry students' conceptual understanding of organic qualitative analysis. *Pedagogical Research, 7*(4), em0132. https://doi.org/10.29333/pr/12307

Arthars, N., Dollinger, M., Vigentini, L., Liu, D. Y. T., Kondo, E., & King, D. M. (2019). Empowering Teachers to Personalize Learning Support: Case Studies of Teachers' Experiences Adopting a Student-and Teacher-Centered Learning Analytics Platform at Three Australian Universities. *Utilizing learning analytics to support study success*, 223-248.

Baah, R., & Anthony-Krueger, C. (2012). An investigation into senior high school students' understanding and difficulties in writing chemical formulae of inorganic compounds. *International Journal of Research Studies in Educational Technology*, *1*(2), 31-39. https://doi.org/10.5861/ijrset.2012.119

Balfakih, N. M. A. (2003). The effectiveness of student team-achievement division (STAD) for teaching high school chemistry in the United Arab Emirates. *International Journal of Science Education, 25*(5), 605-624. https://doi.org/10.1080/09500690110078879

Beka, M. B. (2016). Mother Tongue as a Medium of Instruction: Benefits and Challenges. *International Journal of Language, Litrature & Art Studies. 4*(1), 16-26.

Bencze, L., Bowen, G. M., & Alsop, S. (2002). *Student-teachers' conceptions of science literacy: Socio-political vs. traditional visions. Science Education*, 87(3), 398-419. https://doi.org/10.1002/sce.10029

Berry, J. W. (2006). Stress perspectives on acculturation. *The Cambridge Handbook of Acculturation Psychology*, *1*, 43-56.

Bettelheim, F. A., Brown, W. H., Campbell, M. K., Farrell, S. O., & Torres, O. (2012). *Introduction to general, organic and biochemistry*. Cengage learning.

Bilgin, A. K., Yürükel, F. N. D., & Yiğit, N. (2017). The Effect of a developed REACT strategy on the conceptual understanding of students:" Particulate nature of matter". *Journal of Turkish Science Education*, *14*(2), 65-81.

Bhattacharyya, G., & Bodner, G. M. (2005). "It Gets Me to the Product": How Students Propose Organic Mechanisms. *Journal of Chemical Education, 82*(9), 1402. https://doi.org/10.1021/ed082p1402

Boesdorfer, S. B. (2019). Growing Teachers and Improving Chemistry Learning: How Best Practices in Chemistry Teacher Education Can Enhance Chemistry Education. In *Best practices in chemistry teacher education* (pp. 1-6). American Chemical Society.

Bourdieu, P. (1977). The economics of linguistic exchanges. *Social Science Information*, *16*(6), 645-668.

Budd, J. W. (2004). Mind maps as classroom exercises. *The journal of economic education*, *35*(1), 35-46.

Buthelezi, T., Dingrando, L., Hainen, N., Wistrom, C., & Zike, D. (2020). *Inspire chemistry*. Mcgraw-Hill Education.

Bowen, G. A. (2009). Document analysis as a qualitative research method. *Qualitative Research Journal, 9*(2), 27-40. https://doi.org/10.3316/QRJ0902027

Broman, K., & Parchmann, I. (2014). Students' application of chemical concepts when solving chemistry problems in different contexts. *Chemistry Education Research and Practice*, *15*(4), 516-529.

Carey, S. (2000). The origin of concepts. *Journal of Cognition and Development, 1*(1), 37-41.

Cardellini, L. (2012). Chemistry: Why the subject is difficult? *Educación Química, 23*, 305–310. https://doi.org/10.1016/S0187-893X(17)30158-1

Castro, M., Expósito-Casas, E., López-Martín, E., Lizasoain, L., Navarro-Asencio, E., & Gaviria, J. L. (2015). Parental involvement on student academic achievement: A meta- analysis. *Educational Research Review, 14*, 33-46.

Chen, K., Chen, Y., Ling, Y., & Lin, J. (2020). The individual experience of online chemistry teacher education in China: Coping with COVID-19 pandemic. *Journal of Chemical Education, 97*(9), 3265-3270. https://doi.org/10.1021/acs.jchemed.0c00581

Chesterman, A. (1998). Description, explanation, prediction: A response to Gideon Toury and Theo Hermans. *Current Issues in Language & Society*, *5*(1-2), 91-98.

Chin, C. T. (2004) Conceptions of learning science among high school students in Taiwan: a phenomenographic analysis. *International Journal of Science Education*, 26(14), 1733-1750.

Chu, J. H., Loyalka, P., Chu, J., Qu, Q., Shi, Y., & Li, G. (2015). The impact of teacher credentials on student achievement in China. *China Economic Review, 36*, 14-24. https://doi.org/10.1016/j.chieco.2015.08.006

Clark, R. C., & Mayer, R. E. (2023). *E-learning and the science of instruction: Proven guidelines for consumers and designers of multimedia learning*. John Wiley & Sons.

Copriady, J., Zulnaidi, H., Alimin, M., & Rustaman, R. (2018). In-service Training for Chemistry Teachers' Proficiency: The Intermediary Effect of Collaboration Based on Teaching Experience. *International Journal of Instruction*, *11*(4), 749-760. https://doi.org/10.12973/iji.2018.11447a

Cochran-Smith, M., & Zeichner, K. M. (Eds.). (2009). *Studying teacher education: The report of the AERA panel on research and teacher education*. Routledge.

Collinson, V., Kozina, E., Kate Lin, Y. H., Ling, L., Matheson, I., Newcombe, L., & Zogla, I. (2009). Professional development for teachers: A world of change. *European Journal of Teacher Education*, *32*(1), 3-19.

Concannon, J. P., & Brown, P. L. (2008). Transforming osmosis: Labs to address standards for inquiry: science activities. *Classroom Projects and Curriculum Ideas, 45*(3), 23-26. https://doi.org/10.3200/sats.45.3.23-26

Conner, L., & Gunstone, R. (2004). Conscious knowledge of learning: Accessing learning strategies in a final year high school biology class. *International Journal of Science Education*, *26*(12), 1427-1443.

Cowles, K. V. (1988). Issues in Qualitative Research on Sensitive Topics. *Western Journal of Nursing Research*, *10*(2), 163–179. https://doi.org/10.1177/019394598801000205

Cummins, J. (1981). Age on arrival and immigrant second language learning in Canada: A Reassessment1. *Applied Linguistics*, *2*(2), 132-149.

Cresswell, T. (2009). Place. In *International encyclopedia of human geography* (Vol. 8, pp. 169-177). Elsevier

Creswell, J. W., & Creswell, J. D. (2017). *Research design: Qualitative, quantitative, and mixed methods approach.* Sage publications.

Davis, W. S., & Bowles, F. (2018). Empowerment and intrinsic motivation: A self-determination theory approach to language teaching. *CSCTFL Report*, *15*, 1-19.

Darling-Hammond, L., Wei, R. C., Andree, A., Richardson, N., & Orphanos, S. (2009). Professional learning in the learning profession. *Washington, DC: National Staff Development Council*, *12*(10). Retrieved 20 May 2023 from https://outlier.uchicago.edu/computerscience/OS4CS/landscapestudy/resources/Darling-Hammond,%20Wei,%20Adnree,%20Richardson%20and%20Orphanos,%202009%20%20(1).pdf

Deci, E. L., Vallerand, R. J., Pelletier, L. G., & Ryan, R. M. (1991). Motivation and education: The self-determination perspective. *Educational psychologist*, *26*(3-4), 325-346.

Dewey, J. (1916). Nationalizing education. *Journal of Education*, *84*(16), 425-428.

Duffy, T. M., & Cunningham, D. J. (1996). Constructivism: Implications for the design and delivery of instruction. In D. H. Jonassen (Ed.), *Handbook of research for educational communications and technology* (pp. 170-198). Macmillan

Dragisich, V., Keller, V., Black, R., Heaps, C. W., Kamm, J. M., Olechnowicz, F., ... & Zhao, M. (2016). Development of an advanced training course for teachers and researchers in chemistry. *Journal of Chemical Education*, *93*(7), 1211-1216. https://doi.org/10.1021/acs.jchemed.5b00578

Driel, J. H. V., & Jong, O. D. (2015). Empowering Chemistry Teachers' Learning: Practices and New Challenges. *Chemistry education: Best Practices, Opportunities and Trends*, 99-122. https://doi.org/10.1002/9783527679300.ch5

Eccles, J. S., & Roeser, R. W. (2015). School and community influences on human development. In *Developmental science* (pp. 645-728). Psychology Press.

Erdogan, Y., Bayram, S., & Deniz, L. (2008). Factors that influence academic achievement and attitudes in web based education. *International Journal of Instruction, 1*(1), 31-48.

Fan, S. (2010). Language Shock: A Challenge to Language Learning. *The International Journal of Language Society and Culture, 31*(2), 42-51. https://aaref.com.au/wp-content/uploads/2018/05/31-6.pdf

Farooq, M. S., Chaudhry, A. H., Shafiq, M., & Berhanu, G. (2011). Factors affecting students' quality of academic performance: a case of secondary school level. *Journal of Quality and Technology Management, 7*(2), 1-14.

Fechner, S. (2009). *Effects of context-oriented learning on student interest and achievement in chemistry education* (Vol. 95). Logos Verlag Berlin GmbH.

Fieser, L. F., & Williamson, K. L. (1992). Organic Experiments, 7ª. *Edición DC Heath and Company., New York*.

Fook, C. Y., & Sidhu, G. K. (2015). Investigating Learning Challenges Faced by Students in Higher Education. *Procedia - Social and Behavioral Sciences, 186*, 604-612. https://doi.org/10.1016/j.sbspro.2015.04.001

Fullan, M. (2007). Change theory as a force for school improvement. In *Intelligent leadership: Constructs for thinking education leaders* (pp. 27-39). Dordrecht: Springer Netherlands.

Gabel, D. (1993). Use of the particle nature of matter in developing conceptual understanding. *Journal of Chemical Education, 70*(3), 193-194. https://doi.org/10.1021/ed070p193

Gabel, D. (1998). *The Complexity of Chemistry and Implications for Teaching*. International Handbook of Science Education, 233-248. https://doi.org/10.1007/978-94-011-4940-2_15

Gafoor, K. A., & Shilna, V. (2015). *Perceived difficulty of chemistry units in Std IX for students in Kerala stream calls for further innovations*. Paper presented in Innovations in pedagogy and curriculum: Theory to Practice GBCTE, Kerala, 10th & 11th April 2013.

Galvin, R. (2015). How many interviews are enough? Do qualitative interviews in building energy consumption research produce reliable knowledge?. *Journal of Building Engineering*, *1*, 2-12.

García, O. (2009). Education, multilingualism and translanguaging in the 21st century. *Social Justice Through Multilingual Education*, *143*, 158.

Cohen, J. (2013). *Statistical power analysis for the behavioral sciences*. Routledge.

González, A., & Paoloni, P. V. (2015). Perceived autonomy-support, expectancy, value, metacognitive strategies and performance in chemistry: a structural equation model in undergraduates. *Chemistry Education Research and Practice*, *16*(3), 640-653. https://doi.org/10.1039/c5rp00058k

Graulich, N. (2015). The tip of the iceberg in organic chemistry classes: how do students deal with the invisible? *Chemistry Education Research and Practice, 16*(1), 9-21. https://doi.org/10.1039/c4rp00165f

Guest, G., Bunce, A., & Johnson, L. (2006). How many interviews are enough? An experiment with data saturation and variability. *Field Methods*, *18*(1), 59-82.

Guo, Y., Connor, C. M., Yang, Y., Roehrig, A. D., & Morrison, F. J. (2012). The Effects of Teacher Qualification, Teacher Self-Efficacy, and Classroom Practices on Fifth Graders' Literacy Outcomes. *The Elementary School Journal*, *113*(1), 3-24. https://doi.org/10.1086/665816

Guba, E. G., & Lincoln, Y. S. (1989). *Fourth generation evaluation*. Sage

Hacieminoglu, E. (2016). Elementary School Students' Attitude toward Science and Related Variables. *International Journal of Environmental and Science Education, 11*(2), 35-52. https://doi.org/10.12973/ijese.2016.288a.

Hagaman, A. K., & Wutich, A. (2017). How many interviews are enough to identify metathemes in multisited and cross-cultural research? Another perspective on Guest, Bunce, and Johnson's (2006) landmark study. *Field Methods*, *29*(1), 23-41.

Han, J., & Yin, H. (2016). Teacher motivation: Definition, research development and implications for teachers. *Cogent Education*, *3*(1), 1217819.

Hanson, R. (2017). Enhancing students' performance in organic chemistry through context-based learning and micro activities-a case study. *European Journal of Research and Reflection in Educational Sciences Vol*, *5*(6), 7-20.

Hanushek, E. A., & Rivkin, S. G. (2010). Generalizations about Using Value-Added Measures of Teacher Quality. *American Economic Review, 100*(2), 267-271. https://doi.org/10.1257/aer.100.2.267

Hanushek, E. A. (2011). The economic value of higher teacher quality. *Economics of Education Review, 30*(3), 466-479. https://doi.org/10.3386/w16606

Hargreaves, A., & Fullan, M. (2013). The power of professional capital. *The Learning Professional*, *34*(3), 36.

Hassan, A. A., Ali, H. I., Salum, A. A., Kassim, A. M., Elmoge, Y. N., & Amour, A. A. (2017). Factors affecting students' performance in Chemistry: Case study in Zanzibar secondary schools. *International Journal of Educational and Pedagogical Sciences*, *9*(11), 4086-4093.

Hassan, A. K., Hill, R. A., & Reid, N. (2004). Ideas underpinning success in an introductory course in organic chemistry. *University Chemistry Education*, *8*(2), 40-51.

Hattie, J. (2009). The black box of tertiary assessment: An impending revolution. *Tertiary Assessment & Higher Education Student Outcomes: Policy, Practice & Research*, *259*, 275.

Healy, E. F. (2019). Should Organic Chemistry Be Taught as Science? *Journal of Chemical Education*, *96*(10), 2069-2071. https://doi.org/10.1021/acs.jchemed.9b00122

Hesse-Biber, S. N., & Johnson, R. B. (Eds.). (2015). *The Oxford handbook of multimethod and mixed methods research inquiry*. Oxford University Press

Hill, N. E., & Tyson, D. F. (2009). Parental involvement in middle school: A meta-analytic assessment of the strategies that promote achievement. *Developmental Psychology*, *45*(3), 740-763. https://doi.org/10.1037/a0015362

Hodson, D. (1996). Laboratory work as scientific method: Three decades of confusion and distortion. *Journal of Curriculum Studies*, *28*(2), 115-135.

Hofstein, A. (2004). The laboratory in chemistry education: Thirty years of experience with developments, implementation, and research. *Chemistry Education Research and Practice*, *5*(3), 247-264. https://doi.org/10.1039/b4rp90027h

Hofstein, A. (2005). Chemistry teachers' professional development for the implementation of new content and pedagogical standards. *Chemical Education International*, *6*(1), 1-8.

Hofstein, A., & Mamlok-Naaman, R. (2011). High-School Students' Attitudes toward and Interest in Learning Chemistry. *Educación Química*, *22*(2), 90-102. https://doi.org/10.1016/s0187-893x(18)30121-6

Hoy, A. W., & Woolfolk-Hoy, A. (1993). School of Educational Policy and Leadership. https://www.researchgate.net/profile/Megan-Tschannen-Moran/publication/233187009_Collaborative_learning_A_memorable_model/links/5678548208ae125516ee7e40/Collaborative-learning-A-memorable-model.pdf

Hsiung, W. Y. (2018). The Use of E-Resources and Innovative Technology in Transforming Traditional Teaching in Chemistry and its Impact on Learning Chemistry. *International Journal of Interactive Mobile Technologies*, *12*(7). https://doi.org/10.3991/ijim.v12i7.9666

Hughes, J. N., Wu, J. Y., Kwok, O. M., Villarreal, V., & Johnson, A. Y. (2012). Indirect effects of child reports of teacher–student relationship on achievement. *Journal of Educational Psychology*, *104*(2), 350-365. https://doi.org/10.1037/a0026339

Hussain, I., Suleman, Q., & Din, M. N. U. Din. (2017). Effects of information and communication technology (ICT) on students' academic achievement and retention in chemistry at secondary level. *Journal of Education and Educational Development, 4*(1), 73-93. https://doi.org/10.22555/joeed.v4i1.1058

Ifepe, N. U., & Anekwe, C. E. (2022). Microscale Experiments in Senior Secondary School Practical Chemistry: A Panacea for Improving Students' Achievement and Reducing Cost. *International Journal of Research in Education and Sustainable Development, 2*(7), 14-25.

Jackson, L. (2022). Where Are the Parents? The Lack of Parental Involvement in Students' Academic Achievement. *Scholar Chatter, 3*(1), 7-14. https://doi.org/10.47036/sc.3.1.7- 14.2022

Jarrah, A. M. (2020). Elementary Schools Mathematics and Science Teachers' Perspectives on Using English as a Medium of Instruction. *Humanities & Social Sciences Reviews, 8*(4), 473-482. https://doi.org/10.18510/hssr.2020.8446

James, F. (1980). Monte Carlo theory and practice. *Reports on progress in Physics*, *43*(9), 1145.

Jeynes, W. H. (2007). The Relationship Between Parental Involvement and Urban Secondary School Student Academic Achievement. *Urban Education, 42*(1), 82-110. https://doi.org/10.1177/0042085906293818

Johansen, M. O., Eliassen, S., & Jeno, L. M. (2023). The bright and dark side of autonomy: How autonomy support and thwarting relate to student motivation and academic functioning. *Frontiers in Education,* (Vol. 8, p. 1153647). https://doi.org/10.3389/feduc.2023.1153647

Katsampoxaki-Hodgetts, K., Fouskaki, M., Siakavara, K., Moschochoritou, R., & Chaniotakis, N. (2015). Student and Teacher Perceptions of Inquiry Based Science Education in Secondary Education in Greece. *American Journal of Educational Research*, *3*(8), 968-976. https://doi.org/10.12691/education-3-8-4

Khalaf, A. K. (2000). *The predictors of chemistry achievement of 12th grade students in secondary schools in the United Arab Emirates*. (Doctoral dissertation, The Ohio State University). https://etd.ohiolink.edu/acprod/odb_etd/ws/send_file/send?accession=osu1488193665236293&disposition=inline

Koch, T. (2006). Establishing rigour in qualitative research: the decision trail. *Journal of Advanced Nursing, 53*(1), 91-100. https://doi.org/10.1111/j.1365-2648.2006.03681.x

Kraan, J. (2023). *Supporting autonomous motivation for chemistry in a controlling secondary school environment* (Master's thesis). https://studenttheses.uu.nl/bitstream/handle/20.500.12932/45426/KraanJermo_1525026_RP-final.pdf?sequence=1

Kuhn, T. (1963). The Structure of Scientific Revolutions. *Philosophical Books*, *4*(3), 14-16. https://doi.org/10.1111/j.1468-0149.1963.tb00813.x

Kutsyuruba, B., Walker, K., & Godden, L. (2017). Creating Supportive School Cultures for Beginning Teachers: Mitigating the Cultural Contextual Factors. *The International Journal of Educational Organization and Leadership*, *24*(2), 1-18. https://doi.org/10.18848/2329-1656/cgp/v24i02/1-18

Kurbanoglu, N. I., & Akim, A. (2010). The relationships between university students' chemistry laboratory anxiety, attitudes, and self-Efficacy beliefs. Australian Journal of Teacher Education, 35(8), 48-59.

Lareau, A. (2015). Cultural knowledge and social inequality. *American Sociological Review, 80*, 1-27. http://dx.doi.org/10.1177/0003122414565814

Lee, Y.-A., & Takahashi, A. (2011). Lesson Plans and the Contingency of Classroom Interactions. *Human Studies*, *34*(2), 209-227. https://doi.org/10.1007/s10746-011-9181-1

Leinhardt, G., Stainton, C., & Bausmith, J. M. (1998). Constructing maps collaboratively. *Journal of Geography*, *97*(1), 19-30.

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry*. Sage.

Macaro, E. (2019). Exploring the role of language in English medium instruction. *International Journal of Bilingual Education and Bilingualism, 23*(3), 263-276. https://doi.org/10.1080/13670050.2019.1620678

Malkawi, E. O., Obeidat, S. M., Al-Rawashdeh, N. A., Tit, N., & Ihab, M. (2018). Misconceptions about atomic models amongst the chemistry students. *Int. J. Innov. Educ. Res*, *6*(02), 156-263.

Makombe, G. (2017). An expose of the relationship between paradigm, method and design in research. *The Qualitative Report, 22*(12), 3363-3382. https://doi.org/10.46743/2160-3715/2017.3054

Matthews, P. (2011). *Advanced chemistry*. New York: Cambridge University Press.

Mayer, R. E., & Moreno, R. (2003). Nine ways to reduce cognitive load in multimedia learning. *Educational Psychologist*, *38*(1), 43-52. https://doi.org/10.1207/s15326985ep3801_6

Ming, T., Ling, T., & Jaafar, N. (2011). Attitudes and motivation of Malaysian secondary students towards learning English as a second language. *The Southeast Asian Journal of English Language Studies, 17*(1), 40-54.

Mingers, J., & Brocklesby, J. (1997). Multimethodology: Towards a framework for mixing methodologies. *Omega*, *25*(5), 489-509. https://doi.org/10.1016/s0305-0483(97)00018-2

Moe, J. M. (2011). *Conceptual understanding of science through archaeological inquiry*. Montana State University. Retrieved 20 May 2023 from https://www.proquest.com/openview/7641616d0edf189be7442350d8b9510e/1.pdf?pq-origsite=gscholar&cbl=18750&diss=y

Morrison, R. T., & Boyd, R. N. (1992). *Study guide to organic chemistry*. (6th ed.). Englewood Cliffs, New York: Prentice Hall, Inc.

Montes, L. H., Ferreira, R. A., & Rodríguez, C. (2018). Explaining secondary school students' attitudes towards chemistry in Chile. *Chemistry Education Research and Practice, 19*(2), 533-542. https://doi.org/10.1039/c8rp00003d

Mullis, I. V. S., Martin, M. O., Foy, P., Kelly, D. L., & Fishbein, B. (2020). *TIMSS 2019 International Results in Mathematics and Science*. Retrieved from Boston College, TIMSS & PIRLS International Study Center website: https://timssandpirls.bc.edu/timss2019/international-results/

Napolitano, L. J., Pacholok, S., & Furstenberg, F. F. (2013). Educational Aspirations, Expectations, and Realities for Middle-Income Families. *Journal of Family Issues, 35*(9), 1200-1226. https://doi.org/10.1177/0192513x13479334

NGSS Lead States. (2013). *Next Generation Science Standards: For States, by States*. The National Academies Press.

Nedungadi, P., Malini, P., & Raman, R. (2015). Inquiry Based Learning Pedagogy for Chemistry Practical Experiments Using OLabs. *Advances in Intelligent Informatics*, 633-642. https://doi.org/10.1007/978-3-319-11218-3_56

Nja, C., Cornelius-Ukpepi, B., & Ihejiamaizu, C.C. (2019). The influence of age and gender on class attendance plus the academic achievement of undergraduate chemistry education students at University of Calabar. *Educational Research and Reviews, 14*(18), 661-667. https://doi.org/10.5897/ERR2019.3805

OECD. (2019). *PISA 2018 Results (Volume I): What Students Know and Can Do, PISA*, OECD Publishing, Paris, https://doi.org/10.1787/5f07c754-en

Ogutu, E. A. (2020). *Institution-based Factors Affecting Effective Teaching in Chemistry-a Survey of Secondary School Teachers in Naivasha Sub-county, Nakuru County* (Doctoral dissertation, University of Nairobi). Retrieved 20 May 2023 from http://erepository.uonbi.ac.ke/bitstream/handle/11295/153025/Ogutu%20Emily_Institution-based%20Factors%20Affecting%20Effective%20Teaching%20in%20Chemistry-%20a%20Survey%20of%20Secondary%20School%20Teachers%20in%20Naivasha%20Sub-county%2C%20Nakuru%20County.pdf?sequence=1

Osborne, J., Simon, S., & Collins, S. (2003). Attitudes towards science: A review of the literature and its implications. *International Journal of Science Education, 25*(9), 1049-1079. https://doi.org/10.1080/0950069032000032199

Osma, I., Kemal, F. E., & Radid, M. (2015). Analysis of Determinants and Factors Motivating Students in Higher Education: Case of the Students of Chemistry at the Ben M'sik Faculty of Sciences. *Procedia - Social and Behavioral Sciences, 197*, 286-291. https://doi.org/10.1016/j.sbspro.2015.07.138

Othman, R., Thani, A. M., & Ghani, E. K. (2009). Determinants of Islamic social reporting among top Shariah-approved companies in Bursa Malaysia. *Research Journal of International Studies, 12*(12), 4-20.

Palinkas, L. A., Horwitz, S. M., Green, C. A., Wisdom, J. P., Duan, N., & Hoagwood, K. (2015). Purposeful sampling for qualitative data collection and analysis in mixed method implementation research. *Administration and Policy In Mental Health and Mental Health Services Research, 42*, 533-544.

Patnaik, E. (2013). Reflexivity: Situating the researcher in qualitative research. *Humanities and Social Science Studies, 2*(2), 98-106.

Pintrich, P. R. (2003). A motivational science perspective on the role of student motivation in learning and teaching contexts. *Journal of educational Psychology, 95*(4), 667. https://psycnet.apa.org/doi/10.1037/0022-0663.95.4.667

Ratamun, M. M., & Osman, K. (2018). The Effectiveness of Virtual Lab Compared to Physical Lab in the Mastery of Science Process Skills for Chemistry Experiment. *Problems of Education in the 21st Century, 76*(4), 544-560. https://doi.org/10.33225/pec/18.76.544

Rahman, M. A., & Hasegawa, H. (2011). High levels of inorganic arsenic in rice in areas where arsenic-contaminated water is used for irrigation and cooking. *Science of the Total Environment, 409*(22), 4645-4655.

Roorda, D. L., Koomen, H. M. Y., Spilt, J. L., & Oort, F. J. (2011). The Influence of Affective Teacher–Student Relationships on Students' School Engagement and Achievement. *Review of Educational Research, 81*(4), 493-529. https://doi.org/10.3102/0034654311421793

Pianta, R. C., La Paro, K. M., & Hamre, B. K. (2003). *The classroom assessment scoring system: Findings from the prekindergarten year*. University of Virginia, Center for Advanced Study of Teaching and Learning. *The Elementary School Journal*, 104(5), 409-426.

Piaget, J. (1952). The origins of intelligence in children. *International University*.

Piaget, J. (1973). *The child and reality: Problems of genetic psychology.(Trans. Arnold Rosin)*. Grossman.

Ridge, S. M., Sullivan, F. J., & Glynn, S. A. (2017). Mesenchymal stem cells: key players in cancer progression. *Molecular Cancer*, *16*(1), 31.

Russell, C. B., & Weaver, G. C. (2011). A comparative study of traditional, inquiry-based, and research-based laboratory curricula: impacts on understanding of the nature of science. *Chemistry Education Research and Practice, 12*(1), 57-67. https://doi.org/10.1039/c1rp90008k

Salta, K., & Tzougraki, C. (2004). Attitudes toward chemistry among 11th grade students in high schools in Greece. *Science Education, 88*(4), 535-547. https://doi.org/10.1002/sce.10134

Sancar, R., Atal, D., & Deryakulu, D. (2021). A new framework for teachers' professional development. *Teaching and Teacher Education, 101*(1), 103305. https://doi.org/10.1016/j.tate.2021.103305

Sari, I., Sinaga, P., Hernani, H., & Solfarina, S. (2020). Chemistry Learning via Distance Learning during the Covid-19 Pandemic. *Tadris: Jurnal Keguruan Dan Ilmu Tarbiyah, 5*(1), 155-165. https://doi.org/10.24042/tadris.v5i1.6346

Sanger, M. J., Phelps, A. J., & Fienhold, J. (2000). Using a computer animation to improve students‟ conceptual understanding of a can- crushing demonstration. *Journal of Chemical Education, 77*(11), 1517-1520.

Schmid, G. H. (1996). *Organic chemistry*. Missouri: Mosby-Year Book, Inc.

Seba, J. M., Ndunguru, P. A., & Mkoma, S. L. (2013). Secondary school students' attitudes towards Chemistry and Physics subjects in Tarime-Mara, Tanzania. *Tanzania Journal of Natural and Applied Sciences, 4*(2), 642-647.

Sekaran, U. (2006). *Research Methods for Business*. 6th Edition, United States, Wiley, 44-45.

Shah, S. R., & Abdullah A. (2013). Research Paradigms: Researchers' Worldviews, Theoretical Frameworks and Study Designs. *Arab World English Journal, 4*(4), 252-264.

Shana, Z., & Abulibdeh, E. S. (2020). Science practical work and its impact on students' science achievement. *Journal of Technology and Science Education, 10*(2), 199-215. https://doi.org/10.3926/jotse.888

Sharpe, R., & Abrahams, I. (2019). Secondary school students' attitudes to practical work in biology, chemistry and physics in England. *Research in Science & Technological Education, 38*(1), 84-104.

https://doi.org/10.1080/02635143.2019.1597696

Sirhan, G. (2007). Learning difficulties in chemistry: An overview. *Journal of Turkish Science Education, 4*(2), 2-20.

Sofoklis, S., Rodger W., B., & Bogner, F. X. (2017). PATHWAYS – A Case of Large-Scale Implementation of Evidence-Based Practice in Scientific Inquiry-Based Science Education. *International Journal of Higher Education, 6*(2), 8-19. https://doi.org/10.5430/ijhe.v6n2p8

Stieff, M. (2007). Mental rotation and diagrammatic reasoning in science. *Learning and Instruction, 17*(2), 219-234. https://doi.org/10.1016/j.learninstruc.2007.01.012

Stojanovska, M., Mijić, I., & Petruševski, V. M. (2020). Challenges and Recommendations for Improving Chemistry Education and Teaching in the Republic of North Macedonia. *Center for Educational Policy Studies Journal, 10*(1), 145-166. https://doi.org/10.26529/cepsj.732

Sun, L., Bradley, K. D., & Akers, K. (2012). A Multilevel Modelling Approach to Investigating Factors Impacting Science Achievement for Secondary School Students: PISA Hong Kong Sample. *International Journal of Science Education, 34*(14), 2107-2125. https://doi.org/10.1080/09500693.2012.708063

Surya, W. P., & Arty, I. S. (2021, March). Students' attitudes toward chemistry based on their learning experiences. *In Journal of Physics: Conference Series* (Vol. 1806, No. 1, p. 012178). IOP Publishing.

Smith, M. U., & Scharmann, L. (2008). A multi-year program developing an explicit reflective pedagogy for teaching pre-service teachers the nature of science by ostention. *Science & Education, 17,* 219-248.

Talanquer, V. (2018). Importance of Understanding Fundamental Chemical Mechanisms. *Journal of Chemical Education, 95*(11), 1905-1911. https://doi.org/10.1021/acs.jchemed.8b00508

Taskin, V., & Bernholt, S. (2012). Students' Understanding of Chemical Formulae: A review of empirical research. *International Journal of Science Education, 36*(1), 157-185. https://doi.org/10.1080/09500693.2012.744492

Teplá, M., Teplý, P., & Šmejkal, P. (2022). Influence of 3D models and animations on students in natural subjects. *International Journal of STEM Education*, *9*(1), 1-20. https://doi.org/10.1186/s40594-022-00382-8

Tobin, G. A., & Begley, C. M. (2004). Methodological rigour within a qualitative framework. *Journal of Advanced Nursing, 48*(4), 388-396. https://doi.org/10.1111/j.1365- 2648.2004.03207.x

Tomlinson, C. A. (1999). Mapping a route toward differentiated instruction. *Educational leadership*, *57*, 12-17.

Vaino, K., Holbrook, J., & Rannikmäe, M. (2012). Stimulating students' intrinsic motivation for learning chemistry through the use of context-based learning modules. *Chemistry Education Research and Practice, 13*(4), 410-419. https://doi.org/10.1039/c2rp20045g

Van Brederode, M. E., Zoon, S. A., & Meeter, M. (2020). Examining the effect of lab instructions on students' critical thinking during a chemical inquiry practical. *Chemistry Education Research and Practice*, *21*(4), 1173-1182. https://doi.org/10.1039/d0rp00020e

Van der Merwe, D. (2018). Aspects of academic language proficiency of intermediate phase teacher education students. *South African Journal of childhood education*, *8*(1), 1-9. https://doi.org/10.4102/sajce.v8i1.555

Varga, M. (2017). *The Effect of Teacher Student Relationships on the Academic Engagement of Students* (Masters Dissertation). Retrieved from https://mdsoar.org/handle/11603/3893

Vermaat, H., Kramers-Pals, H., & Schank, P. (2003, October). The use of animations in chemical education. In *Proceedings of the international convention of the association for educational communications and technology* (pp. 430-441).

Vygotsky, L. S. (1978). *Interaction between learning and development. Mind in society* Cambridge, MA: Harvard University Press.

Ward, C., & Kennedy, A. (1993). Psychological and Socio-Cultural Adjustment During Cross-Cultural Transitions: A Comparison of Secondary Students Overseas and at Home. *International Journal of Psychology*, *28*(2), 129-147. https://doi.org/10.1080/00207599308247181

Ward, C., & Kennedy, A. (2006). *Cross-cultural adaptation of international students: The impact of psychological and socio-cultural factors. Journal of Cross-Cultural Psychology, 37*(2), 158-174. https://doi.org/10.1177/0022022105282296

Weaver, D. L., Ashikaga, T., Krag, D. N., Skelly, J. M., Anderson, S. J., Harlow, S. P., ... & Wolmark, N. (2011). Effect of occult metastases on survival in node-negative breast cancer. *New England Journal of Medicine, 364*(5), 412-421.

Wentzel, K. R. (2002). Are effective teachers like good parents? Teaching styles and student adjustment in early adolescence. *Child Development*, 73(1), 287-301.

Willett, B. P. (2014). *Demystifying the advisor's role in doctoral students' persistence during the dissertation stage* (Doctoral dissertation, The Florida State University).

Wu, H.-K., Krajcik, J. S., & Soloway, E. (2001). Promoting understanding of chemical representations: Students' use of a visualization tool in the classroom. *Journal of Research in Science Teaching*, *38*(7), 821–842. https://doi.org/10.1002/tea.1033

Zeidler, D. L. (2002). Dancing with Maggots and Saints: Visions for Subject Matter Knowledge, Pedagogical Knowledge, and Pedagogical Content Knowledge in Science Teacher Education Reform. *Journal of Science Teacher Education*, *13*(1), 27-42. https://doi.org/10.1023/a:1015129825891

Zhao, W. (2023). How to encourage students in learning chemistry? *National Science Review*, *10*(10), nwac267. https://doi.org/10.1093/nsr/nwac267

Ziling, Z., & Yan, L. (2018). A Comparative Study on the Competitiveness among Japanese, American, German and Chinese Automobile Brands in Chinese Market. *Innovation and Management*, 16-30.

Zumdahl, S. S., & Zumdahl. S. A. (2003). *Chemistry* (6th ed.). New York: Houghton Mifflin Company.

Appendices

Appendix A

Ethical Approval Letter

Social Sciences Ethics Committee - Research / Course
Date: 07/11/2023

This is to certify that application No:ERSC_2023_2474, titled: FACTORS INFLUENCING UAE HIGH SCHOOL CHEMISTRY STUDENTS' LEARNING OF ORGANIC QUALITATIVE ANALYSIS: A QUALITATIVE STUDY, submitted by Manal Almahdawi has been reviewed and approved by UAEU Social Sciences Ethics Committee - Research / Course on 01/11/2023.

Sincerely,
Chair of the UAEU Social Sciences Ethics Committee - Research / Course Research Ethics Sub-Committee
United Arab Emirates University

Appendix B

Observation Checklist on Teaching Organic Qualitative Analysis (OCTOQA)

The purpose of this observation checklist is to find out from chemistry teachers and students whether the intended purposes of the lesson have been achieved. There are two sections (A and B). Section A seeks general information about teachers and students, Section B seeks expectations from teachers and students.

Section A

General information about the teacher and students.

⇒ Teacher's Name: …….
⇒ Number of years in teaching Chemistry: …….
⇒ Gender (Teacher):_____Male _____Female
⇒ Qualification:___Bachelor _____Master_PhD
⇒ Observer's Name:
…….
⇒ Date of Observation: …….
⇒ Class Section: A: [ ] B: [ ] C: [ ] D: [ ]
⇒ Period number: …….
⇒ Number of students in class:…….
⇒ Duration of lesson: ……
⇒ Gender of the students: Male [ ] Female []

Section B

Item	Yes	No
Factors related to teacher and students		
1- The teacher demonstrates good command of the subject matter in organic qualitative analysis.		
2- The teacher uses an effective lesson plan to guide lesson implementation		
3- The teacher uses suitable resources (i.e., organic models) to teach organic functional group detection.		
4- The teacher uses hands-on activities to support students' conceptualunderstanding in (OQA).		
5- The teacher revises previously taught concepts before introducing the new lesson and connects previous concepts to the new lesson on OQA.		

6- The teacher selects suitable teaching methods & strategies to meet the needs ofindividuals and groups of students (Differentiation) while teaching OQA.		
7- The teacher provides appropriate and constructive feedback to his students onOQA.		
8- The teacher supports his students to help identify solutions to areas of weakness they may have in learning OQA.		
9- The teacher demonstrates positive teacher-student interaction and good relationship with students while teaching OQA.		
10- The teacher continuously assesses his students' learning and understanding ofOQA.		
11- Students demonstrate understanding and awareness of new concepts in OQA.		
12- The teacher activates questioning between students and the teacher related to thetopic OQA.		
13- The teacher activates classroom dialogue between students and the teacher related to the topic OQA.		
14- Students show engagement in learning OQA.		
15- Students take responsibility for their learning of OQA.		
16- The teacher promotes students' independent learning of OQA.		
17- The teacher promotes students' critical thinking and problem-solving related tothe lesson in OQA.		
18- Students' & the teachers use English language in instruction and discussion onthe topic of OQA.		
19- The teacher encourages students' collaborative tasks in working together in pairsor groups while learning OQA.		
Factors related to Instructional Materials		
1- The instructional materials encourage the use of learning technologies to conceptualize OQA.		
2- The lesson activities designed to support inquiry learning for OQA.		
3- The lesson plan has clear and appropriate learning objectives.		

4- The instructional materials are organized and present content in a logical progression.		
5- The lesson activities are selected according to students' needs		
6- The lesson activities are selected according to students' interests.		
7- The lesson activities are selected according to students' abilities.		
8- The lesson activities are fun and enjoyable.		
9- The lesson plan includes independently performed worksheets as an assessment method.		
10- The lesson plan includes oral discussions as an assessment method.		
11- The lesson plan includes quizzes with short series of questions as an assessment method.		

Appendix C

Semi-Structured Interview Protocol

Study Research Questions:

1. What factors influence 12th -grade UAE students' understanding of organic qualitative analysis?
2. What are the challenges that 12th grade students face in conceptualizing organic qualitative analysis and how to overcome these challenges?
3. What sort of support do 12th grade students need to better understand organic qualitative analysis?

Possible prompt questions (Semi interview questions)

- Are you familiar with Organic Qualitative Analysis (OQA)?
- Can you explain the concept of organic qualitative analysis and its importance in determining the structure of an unknown organic compound?
- Can you illustrate one example?
- What methods of OQA did you use in your teaching/learning?
- Do you have all the required facilities /equipment and reagents to study OQA?
- How many organic compounds did you analyze in the last semester in Grade 12?
- Can you specify one method that you used on OQA last time?
- What chemicals did you use? What procedure did you apply? Can you explain more on it?
- What difficulties did you face as you were learning how to recognize functional groups in OQA?
- If you were learning Organic Qualitative Analysis today, what would you expect?
- Does the teacher use any models to help you understand this subject better?
- Does your teacher use theory or apply practical skills when teaching this subject?
- How many times a week do you go to the lab and work on experiments?

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UAEU DOCTORATE DISSERTATION NO. 2024: 47

The research investigates the factors affecting 12th-grade Emirati students' understanding of organic qualitative analysis in chemistry, focusing on challenges highlighted by international assessments like PISA and TIMSS. Using a qualitative approach, the study gathered data through interviews, classroom observations, and document analysis, recommending a shift toward practical-based teaching methods to enhance learning outcomes and contribute to global educational improvement.

Manal Almahdawi received her PhD in Curriculum and Instruction from the Department of Curriculum and Instruction, College of Education at the United Arab Emirates University, UAE. She received her PhD of Curriculum and Instruction from the College of Education, United Arab Emirates University, UAE.

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