



**Investigating High School Science Teachers’
Perceptions and Practices of Science Virtual
Laboratories in American Schools in Ajman, UAE**

بحث أستقصائي في تصورات وممارسات معلمي العلوم بالمرحلة
القانونية في مختبرات العلوم الافتراضية في المدارس الأمريكية في
عجمان.

by

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of the requirements for the degree of
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ABSTRACT

Despite the positive impact of the virtual lab experimentation, the teachers are not using labs for scientific experiments and investigations effectively in quality and quantity. Even the virtual labs applications are not used regularly or effectively. Thus, this research study aimed at investigating high school science teachers' perceptions and practices of science virtual laboratories in private schools following US curriculum in the emirate of Ajman in the United Arab Emirates. A mixed method approach was employed to collect qualitative and quantitative data via valid and reliable questionnaire. The study targeted a group of high school science teachers of grades 9-12, teaching biology, chemistry and physics in three American curriculum schools based in Ajman-UAE. Four research questions were crafted to guide the study and achieve the purpose of the study. The research problem stemmed from the acknowledgement of insufficient practical integration of virtual lab in science instruction. The results of the study found out that teachers had adequate knowledge of virtual laboratories; teachers agreed on what they needed to improve their own practices and assured the success of using virtual laboratories in high school science lessons, and schools are required to provide students with sufficient resources. Besides teachers stated that they did not receive appropriate training on how to use and conduct virtual laboratories. Despite the limitations of the current study, its significance lies in being a stepping-stone to start conversations on the matter at hand and motivate further investigation into the effectiveness and methods of integrating virtual laboratories in science classes as a whole.

Keywords: virtual lab, Science teachers, perception, practices

الملخص

على الرغم من الأثر الإيجابي لتجارب المختبرات الافتراضية، إلا أن المعلمين لا يستخدمون المختبرات للتجارب العلمية والاستقصاءات بشكل فعال نوعاً وكماً، بالإضافة إلى أن تطبيقات المختبرات الافتراضية لا تُستخدم بانتظام أو بشكل فعال. لذلك، تهدف هذه الدراسة إلى البحث في ممارسات معلمي العلوم بالمدارس الثانوية وتصوراتهم عن المختبرات الافتراضية في المدارس الخاصة في إمارة عجمان بدولة الإمارات العربية المتحدة، حيث تم استخدام نهج الطريقة المختلطة لجمع البيانات النوعية والكمية من خلال استبيان صحيح وموثوق. وقد استهدفت الدراسة مجموعة من مدرسي العلوم بالمرحلة الثانوية من الصف التاسع إلى الثاني عشر، يدرسون علم الأحياء والكيمياء والفيزياء، في ثلاث مدارس تتبع مناهج أمريكية، في إمارة عجمان بالإمارات. تمت صياغة أربعة أسئلة بحثية لتوجيه الدراسة وتحقيق الغرض منها، وكانت مشكلة البحث تنبع من عدم كفاية التوظيف العملي للمختبر الافتراضي في تدريس مواد العلوم. وأظهرت نتائج الدراسة أن المعلمين لديهم معرفة كافية بالمختبرات الافتراضية، واتفق المعلمون على احتياجاتهم فيما يتعلق بتحسين ممارساتهم وضمان نجاح استخدام المختبرات الافتراضية في دروس العلوم بالمدارس الثانوية، وتبين أنه على المدارس تزويد الطلاب بالموارد الكافية، كما ذكر المعلمون أنهم لم يتلقوا التدريب المناسب على كيفية توظيف المختبرات الافتراضية وإجراء تطبيقاتها. وعلى الرغم من القيود في الدراسة الحالية، تكمن أهميتها في كونها نقطة انطلاق لبدء النقاش حول المسألة المطروحة وتحفيز المزيد من البحث في فاعلية المختبرات الافتراضية وأساليب دمجها في فصول العلوم ككل.

DEDICATION

Completing this dissertation has been one of the wonderful moments in my life; writing this dissertation gave me the chance to achieve a dream I have always dreamed about.

This accomplishment is dedicated to the soul of my lovely mother, to my father who always believed in me, to my dear husband who supported and encouraged me to have a successful career, and finally to my amazing and lovely kids, Yara, Basel, Naya and Alma, for their lovely wishes and smiles, for understanding my busy nights. This could not have been possible without all the support and love provided by my extraordinary family.

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Never giving up is the only way we can achieve what we expected as impossible!

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Table of Abbreviations

ABBREVIATION	DESCRIPTION
UAE	United Arab Emirates
CPD	Continuous Professional Development
VL	Virtual Laboratories
ADEC	Abu Dhabi Education Council
ICT	Information and communication-Technology
STEM	Science, Technology, Engineering and Math
AI	Artificial Intelligence
Apps	Applications
NGSS	Next Generation Science Standards
4IR	The Fourth Industrial Revolution
MOE	Ministry of Education
OCL	Online Collaborative Learning
US	United States
MENA	Middle East and North Africa
LMS	Learning Management System
TGK	Technological Pedagogical Knowledge

CHAPTER 1

1.1 Introduction

A Science student asked his teacher, “What would happen if I conducted this experiment in class?” The teacher replied, “You cannot possibly conduct such an experiment in the science laboratory we have since we do not have the required resources for the experiment, and it would be dangerous.”

The above is a common scenario in science classes that affects the students’ learning experience. In most cases, the reasons are lack of resources, safety concerns, time constraints, and probably the teachers’ readiness to tackle challenges.

Soon, the next generation will face a massive responsibility for many severe and vital issues. The world is growing incredibly fast, creating many challenges that our future and next-generation science students have to solve and learn from. The students will be in various decision-making scenarios, such as global warming, vaccination, cures for genetic diseases, cancer-free community, and others. The next generation could develop creative and innovative solutions to face all such challenges. Ozkan et al. (2021) highlighted a strong linkage between science and knowledge theories and practices in their study. Due to the industrial revolution, rapid environmental issues have emerged, which students should be able to identify and provide practical solutions for.

Over the years, science has focused on students understanding and explaining the phenomena around them. The students need to improve competencies, which require active and interactive science classes.

It is generally agreed that science teaching should be based on practical applications. Since science in the real world is pretty much based on experiments, and scientific breakthroughs take place inside laboratories, teachers should consider incorporating scientific experiments in science education. In fact, practical applications of all sciences should be a key component of schoolwork.

Hands-on and practical science activities are becoming an integral part of science teaching and learning locally and beyond, with an increase in the focus on practical work in the curricula and instructional methods of science subjects (Alneyadi 2019). In addition, providing students with experience and expertise that align with science instructional goals is at the heart of good scientific practices. It is therefore only through laboratory learning activities that science can be presented and learned effectively (Omiko 2007). Unfong (2009) reiterated this, highlighting the effectiveness of laboratory classes in enhancing the instruction of science subjects and enriching students' practical experiences.

Science classes should be exciting and engaging, which shall help the students achieve their learning goals and prepare them for real-life situations and future careers. Furthermore, Bridgeland, Dilulio & Morison (2006) noted that the leading cause of students dropping out of school is the irrelevance of school activities and boredom.

The United Arab Emirates (UAE) is among the countries that took note of the importance of the practical aspect of teaching. It adopted a new approach to education that emphasizes practical science work to prepare citizens for post-oil life. To achieve sustainable socio-economic development, the UAE invests heavily in innovative initiatives in a wide range of sectors, including education, and focuses on human development and economic diversity for the benefit of future generations. The Emirates' National Innovation Strategy (2015) aims to fulfil national aspirations and address international challenges by enhancing science- and technology-based innovation; it also enables huge and rapid steps in achieving change. Science curricula are designed to provide students with the opportunity to plan and conduct investigations, communicate their knowledge and understanding, and develop scientific thinking and problem-solving skills (ADEC 2017). As part of its commitment to this strategy, Abu Dhabi Education Council (ADEC) developed the STEM initiative, which aims to improve science education services, provide consultation, and provide high-quality science courses as well as to provide science education. Acknowledging the fact that laboratory learning is of paramount importance, science educators will also be prepared and trained through the program, by supplementing interdisciplinary coursework with hands-on laboratory experience (ADEC 2017).

With technology driving advances in all fields of knowledge, the innovative trend of practical work in science education has been directed towards virtual laboratories (VLs). In concept, artificial intelligence (AI) aims to develop machines that mimic, extend, and expand human intelligence by working and reacting just like humans. AI is used for activities such as speech recognition, learning, planning, problem solving, and manipulating and moving objects (Xinhua & Lin 2018). Hence, robotics and virtual laboratories are the best tools for demonstrating the practical application of AI. As a matter of fact, the field of robotics is one of the most important in artificial intelligence. To be able to perform the various activities of mapping, motion planning, manipulation, problem solving, and navigation, robots require AI. On the other side, there are virtual laboratories that can replace traditional labs through digital apps simulations and programmed manipulative activities (Scheckler 2003). virtual laboratories offer themselves as an ideal solution for many scenarios. They can provide equal access for all students, playing an active role in inclusion and maximizing learning opportunities for all. In addition, in a situation where there may be insufficient educational facilities, not only do virtual laboratories allow the continuation of learning, but they also keep the students up to date on the most recent technological and scientific advances and breakthroughs.

1.2 Background of the Research

Humans could survive thousands of years by doing and learning primary science, asking what, why, and how, leading them to many theories, explanations, and even inventions. To date, humans still are dependent on doing and learning science, albeit with more help and support of technology and engineering practices.

Students are expected to graduate from school equipped with 21st-century skills: creativity, communication, collaboration, and critical thinking. Students have to analyse and evaluate evidence in their hands without neglecting literacy skills. Students understand the information around them in the three skills: information literacy, media literacy, and technological literacy (Kim, Raza & Seidman, 2019).

From the very beginning, science education communities have been aware of the value and worth of inquiry learning in science to master students' knowledge and skills. Thi, Hang, & Srisawasdi (2021) suggested that although the Next Generation Science Standards (NGSS) did not bring anything new by encouraging learning science through practice, it showed the impact of learning content through engineering practices. He further noted that NGSS was developed due to the need to produce a well-prepared young generation who can compete locally and globally. Thus, the implementation of NGSS is urgent and crucial (NSTA 2013).

Science laboratories are central tools to learn science through practice, demonstrations, investigations, and experiments. Nevertheless, face-to-face or traditional science laboratories could have some restrictions and limitations such as time and shortage of resources, budget, and equipment, rules and regulations, make-up laboratory classes for absentees, lack of access to special needs students (Lunetta, Hofstein, & Clough 2007). The concept of remote experiments or virtual laboratories lends itself well in this area. Moosvi, Reinsberg & Rieger (2019) defined a remote experiment as any experiment students can perform in different places and only through the internet. Moreover, Pavlou (2020) described virtual labs as a way for students to practice in a safe, online environment, whereby they can interact with elements, machines, and interfaces, through virtual science laboratory games and simulation software. Giannaka, Alexiou & Bouras (2005) added that Virtual Laboratories also involve the design, development and realization of pre-determined experiments which stimulate activities and processes that could happen in real-life situations. Such laboratories can either complement the existing school laboratories or as independent laboratories, especially for courses where the real labs cannot be developed due to practical limitations.

Consequently, with technology invading the education sector, (Al-Rsa'i 2013) stated that in terms of pedagogy, ICT offers a significant opportunity to implement learning theories that place students at the centre of learning situations (Learner-Centred Pedagogy), equip them with solid reasons to continue learning, and motivate them to search and research. Therefore, an alternative and supportive solution could be introduced. Students can have

the chance to carry out science experiments by using virtual laboratories, and it could be even more effective than a regular science laboratory (Trundle & Bell 2010).

1.3 Statement of the Problem

It has been acknowledged in the Emirati context that the use of virtual lab in science education is not spreading widely, as discussed in a current study carried out by Alneyadi (2019) whose results concluded that “the teachers are not using labs for scientific experiments and investigations effectively in quality and quantity. Even the virtual labs applications are not used regularly or effectively.” Additionally, Alneyadi (2019) added that only half of the science teachers reported that virtual labs activities impacted the science instruction positively and enhanced the students’ knowledge, skills, abilities, attitudes, and innovation. However, their virtual labs implementation and uses were still humble, limited, and in the developing infancy stage. Indeed, as a science educator for more than ten years, virtual implementation has been not used widely due to the lack of resources, programs, and technical or digital experience of the teachers.

Head & Scrubber (2006) reported that in 1984, Scholastic Software created a virtual dissection frog. The simulation provided all the required scientific knowledge in an actual dissection. Since then, science and technologies have improved and developed rapidly, creating many virtual labs and simulations.

Technological advances that evolved during the Fourth Industrial Revolution (4IR) have changed the world’s educational paradigm. The paradigm shift is part of learning in the 21st century. As proposed by Rusilowati et al. (2016), education in the 21st century is an era of accelerating information and increasing knowledge, supported by digital media and technology and promotes innovative approaches of students (Patton & Santos 2018).

Ananga (2020) stated that technology improves educational activities by making every classroom effective. Therefore, using technical tools for effective and efficient education is essential to achieve educational goals. However, many researchers investigated virtual science laboratories in different countries. Wong, Chen & Chang. (2020) concluded that most students found virtual laboratories helpful and accessible in their study. In addition, students showed full readiness for innovative technology.

The research conducted by Musawi et al. (2017) in Omani schools showed the same positive attitude towards virtual laboratories, resulting in a positive attitude towards virtual laboratories. Another study by Lee & Osman (2021) summarized that UAE students had a positive attitude towards online learning. These results came out with a short period of online learning. Bawa'aneh (2021) highlighted that the readiness of the Ministry of Education (MOE) and Infrastructure of the UAE as a whole country resulted in the UAE students reporting satisfaction with their education during distance learning. It could be inferred that MoE has been trying to reform science education by providing digital resources and VL is not an exception; however, the implementation is in need of more efforts and enhancement.

Technological coupling of science education and the student's readiness and satisfaction with online experience provide a rationale for investigating the practices and perceptions of high school science teachers regarding science virtual laboratories in UAE-Ajman American schools.

1.4 Purpose of the Study

The UAE has given considerable attention to education since its establishment in 1971, with a deeply-rooted conviction that the next generation can transform the country through solid education (Alhebsi, Pettaway & Waller 2015). As reported on the United Arab Emirates Government portal in 2021, the UAE allocated a AED 10.146 billion budget for education for the year 2020. The government directly stated that the Ministry of education's move is in line with the wise leadership's national visions to achieve sustainable education by highlighting the need for continuous lifelong learning, as well as enhancing the role of technology in serving the educational process.

The UAE adopted and initiated several digitalized learning environment and forms, namely Hamdan Bin Mohammed Smart University, as the first accredited E-learning University. Students can learn remotely; yet have the opportunity to engage, learn, and have access to

online lessons. The students of this university are provided with a flexible and adaptive platform with resources for a successful learning experience (Procter 2020).

H.H. Sheikh Mohammed bin Rashid Al Maktoum, Vice President and Prime Minister of the United Arab Emirates and Ruler of Dubai, launched an initiative in 2012 to create an intelligent learning environment in the UAE schools by distributing smart devices to students and upgrading the networks to 4G in all schools (MOE 2021).

Considering the importance of laboratories in teaching science and inspired by the UAE's vision of integrating technology in education, this study will examine virtual laboratories in science education in UAE-Ajman. As reiterated, for science to be taught effectively and adequately, labs need to be included as part of the science curriculum (NSTA 2009).

This study aims to investigate high school science teachers' perceptions and practice of science virtual laboratories. To that end, this study will attempt to answer the following research questions.

1.4.1 Research Questions

1. What are the aspects of high school science virtual laboratories in the UAE-Ajman?
2. What are the perceptions of high school science teachers regarding virtual laboratories in the UAE-Ajman?
3. What are the virtual laboratory practices of high school teachers in the UAE-Ajman?
4. What demographic differences do high school science teachers have regarding their perception of virtual laboratories in the UAE-Ajman?

1.5 Significance of the Study

The UAE is considered a pioneer in the region by investing funds and resources in integrating technologies in education and producing a well-equipped new generation with

all necessary life skills in the era of technology. Alaleeli & Alnajjar (2020) noted that “the United Arab Emirates (UAE) is among the most technologically advanced markets in the region and a leading country at the forefront of digital transformation, particularly for e-commerce, AI technology, and intelligent learning development.”

This study is deemed significant for four main reasons. First, it shall enrich the previous studies and research on virtual laboratories in the UAE high school science classes. According to Brinson (2015), only 56 comparative studies published from 2005 to 2014 reported learning outcomes of distance labs and compared distance labs to face-to-face teaching labs.

Second, this study will be the first study to investigate virtual laboratories in Ajman. This can provide essential data for school leaders and decision makers to take on a series of actions, especially with the recently published framework of Ministry of education focusing on technology integration in educational pedagogy in learning classes.

Third, this study shall investigate teachers’ perceptions and practices in using virtual laboratories in high school science classes. Ambusaidi et al. (2018) highlighted the advantages of virtual laboratories in science classes. In addition, the study concluded that virtual labs could be as effective as traditional labs in achieving the desired learning outcomes.

The fourth element contributing to the significance of this study is the flow and comprehensiveness of the research. The research consists of the 3 aspects—starting from curriculum design, to practices and perceptions of teachers as the core pillar in the process, and finally studying the impact of the demographic differences on the perceptions and practices.

1.6 The Structure of the Dissertation

This study consists of five chapters, starting with Chapter 1, the Introduction. This chapter sheds light on the background of the research, defines the main terms, and states the

research problem. In addition, the purpose and questions of the study, as well as the rationale and the importance of the study are discussed. Chapter 2 presents the theoretical framework and literature review. It examines details relevant to virtual laboratories in science education. It also reviews the types of virtual laboratories, as well as and the advantages and impacts of virtual labs. Chapter 3 introduces the methodology of the study, identifying the types of data collected, the sample participants, instruments used, and the testing of reliability and validity of the study. In chapter 4, collected data is analysed and an interpretation of the results us presented.. Finally, Chapter 5, The Discussion and Conclusion, outlines the study's findings along with the limitations and recommendations.

CHAPTER 2: Theoretical Framework and Literature Review

The era of technology makes learning possible at any time and place. Students should be equipped with skills to keep up with the advances of the 21st century. They are expected to develop skills to apply, analyse, collaborate, solve problems, and make decisions using their educational technologies.

This research aims to investigate the practices and perceptions of high school science teachers with regard to science virtual laboratories as part of educational technology pedagogy in science education.

This chapter is divided into subsections to shed light on the literature review logically. The first section discusses the theoretical framework and related literature.

The literature review section will discuss the concepts presented in the previous chapter: an overview of Science and Technology, Digital curriculum, UAE and technology, and Virtual laboratories. The next section defines virtual laboratories, compares between virtual laboratories and face-to-face (traditional laboratories), and presents related literature.

2.1 Theoretical Framework

This section explores the theories relevant to technological integration with science education pedagogy. Theories considered in this study are cognitivism, constructivism, and connectivism, online collaborative learning OCL, and NGSS framework.

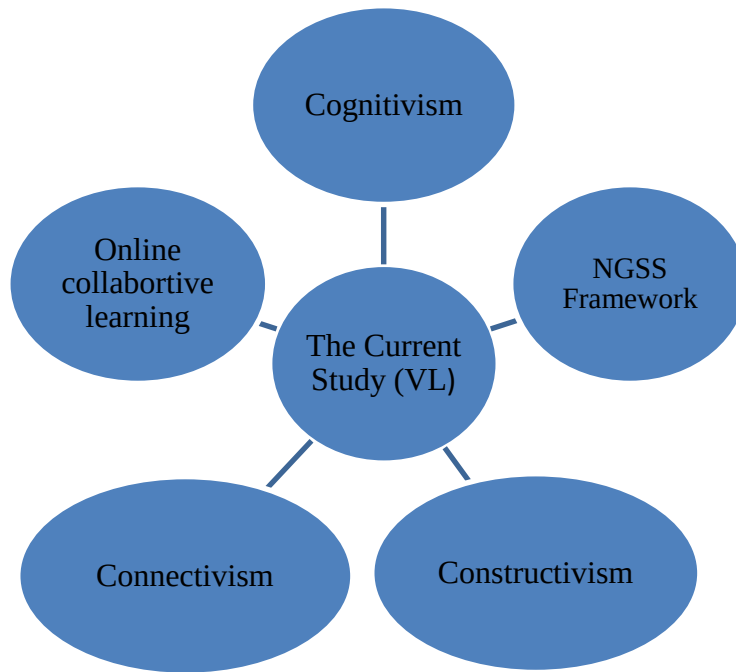


Figure 1: The Study's Theoretical Framework

2.1.1 Cognitivism Theory

Students think in their own unique ways, using their five senses to think and process the information they receive. Nowadays, the majority of students acquire most of their knowledge and information through digital resources. The information gained digitally highly impacts students' thinking as they are required to adapt and link data to real-life experience, thus making the students process information more cognitively. Elsayary, Forawi & Mansour (2015) proposed that cognitive learning relies heavily on critical thinking, creativity, and innovation skills. Additionally, Ouyang and Stanley (2014) suggested that all cognitive skills can be developed through digital learning. Hence, this study explores the science teachers' perception of virtual laboratories in relation to developing the students' critical thinking skills.

2.1.2 Constructivism Theory

Science is learned and built through inquiries, and nothing is better than using science laboratories to solidify students' knowledge and education. This belief is in line with Piaget (1926), who introduced the constructivism theory, where the core is that students

learn by doing. Ümran (2018) emphasized that in constructivism, the teacher guides the learners to organize their learning by providing a suitable environment. Additionally, Ackermann (2001) supported Piaget and Papert's claim that students should be provided with engaging opportunities like hands-on exploration for the successful constructive process, building on the child's own constructed knowledge.

Fernando & Marikar (2017) asserted that the constructivist teaching and learning theory advocates a participatory approach in which students actively participate in the learning process. This approach can be executed through science laboratories, where students are offered the chance to explore and engage actively in the learning process. The technological advances save students' efforts, allow more time to construct the knowledge, and ensure engagement and learning.

Duffy & Jonassen (1992) argued that current educational technology practices should be mentored through a constructivist paradigm. Students can have the chance to design and redesign their virtual laboratories several times with different variables. This will relieve teachers from planning detailed previous known results and allow students more space and autonomous learning. Bourdeaux (2017) claimed that technology could inspire teachers to be co-learners with their pupils. Furthermore, technology could give the teachers the chance to play an integral role in the students' learning process by providing them a space to design their learning experiences.

Moreover, Wheatley (1991, cited in Yurdakul 2005) highlighted that constructivism entails that each learner has the opportunity to learn by themselves, being able to construct and interpret the information and observations through their own experience.

2.1.3 Connectivism Theory

In modern education, technology is present in most classrooms. Connectivism theory was the result of technology invading the teaching process. This theory was introduced by Siemens in 2004. Downes, Canada & Road (2019) described connectivism as "a network theory of knowledge and learning with an emphasis on using digital technology to enhance and extend interaction online". Baldwin (2019) described how new opportunities are created for people by digital applications as result of connectivism. Additionally,

connectivism emphasizes that knowledge is distributed across an information network and can be stored in various digital formats (Kop & Hill 2008).

The connectivism leaning theory links all pillars together; students, tools, and the shared knowledge at the end of networking connected process. On the other hand, the instructor has a distinctive role to choose carefully and purposefully the digital tools to assure individualized ecosystem for the students (Banihashem, et al. 2017).

In connectivism theory, learning is not limited to students' internal construction of information; students can gain knowledge from external networks (Aldahdouh, Osorio & Caires 2015). Alzain (2019) highlighted that the significance of the connectivism theory in collaborative environments is visible in social networks. That is, collaborative learning means learning via networking with humans such as learners, teachers, and experts utilizing non-human resources like books, databases, web, blogs, and the like.

Ravenscroft (2011) further remarked that the unlimited opportunities of options and possibilities virtual laboratories could provide, with no count for long-term experiments, match the principles of connective theory. This is made possible through learning by gathering information from different resources and opinions, up-to-date knowledge, and deciding as part of the learning process. Kasperuniene (2017) suggested that connectivism principles are more focused on the technical means and the individual as the subject and its importance. Thus, a balanced view between the learners and any technological advancement in the class should always be given appropriate consideration; connectivism is more able to explain online networking dynamics and the socio- technical context of the online learning in science lessons (Jung 2019).

2.14 Online Collaborative Learning (OCL)

Haraism (2012) introduced the online collaborative learning (OCL) theory as a result of online learning expansion, by providing adaptation of the internet to the learning environment, it aimed to enhance collaborative learning and fostering knowledge. (Vaughan, et al. 2020) added that OCL has three phases of knowledge construction where learning can be supported and shaped in sustainable learning; students can generate, analyse, compare, and synthesise ideas.

In OCL students are encouraged to work and learn collaboratively with their peers and colleagues; teachers can perform the role of a facilitator to build their knowledge and enhance their learning experience (Picciano 2017). Online collaborative learning creates interactions between learners and can support the social and communication skills. This method opens the doors widely to many options in teaching methods to increase the students' motivations and enhance their achievements.

Enhancing students' positive attitude towards technology and eliminating negative attitude towards its usage, especially with students that do not have technological self-confidence and are afraid of using technological devices, will lead to successful implementation of applications such as virtual laboratories (Sivakumaran and Lux, 2011). Collaborative learning is not limited to face to face learning, technological communication tools and information support and develop the students capabilities and skills, as well as enrich their learning. The internet is an integral tool to achieve interactions and collaboration among learners.

The current education system enforces the ability of the students to access and use computer devices, online tools and resources, bringing the benefits of collaborative learning techniques, such as the increase in student-student interaction and working with the students in groups (Roberts, 2004).

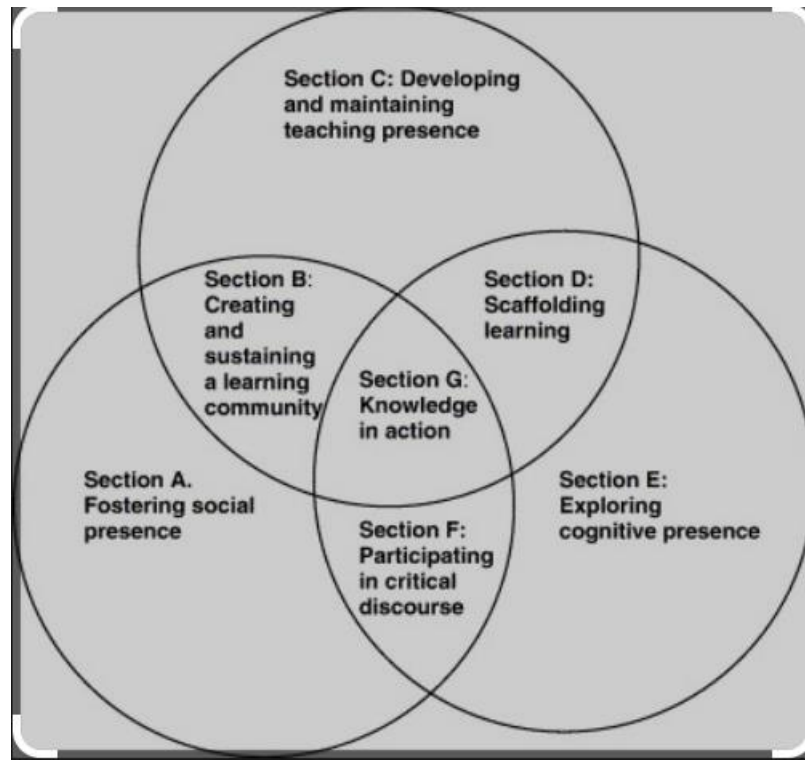


Figure 2: Online collaborative learning framework (Adapted from Garrison, Anderson, and Archer's community of inquiry model, 1999)

2.1.5 Next Generation Science Standards (NGSS) Framework

In 2013, the National Research Council completed and published the new science education framework, the new framework focused on skills and engineering practices. Simpson, Sunder & Gabler (2017) reported that the new science framework (NGSS) has been adopted and implemented in the U.S states, and MENA area.

The NGSS sprung from the need and deficiency in previous frameworks; it intends to improve students' skills, practices and knowledge of technology. As core skills should be emphasised, to achieve the goals of this new approach, teachers should adopt and use new and different type of mind-set and planning (Harris, Sithole & Kibirige 2017).

The NGSS contains three dimensions; the core ideas, engineering and scientific practices, and the interdisciplinary concepts. The three dimensions should be taken as one set in adopting NGSS. In addition, they should be integrated in curricula, teaching, learning and assessments (NGSS 2013) .

The NGSS (2013) focused on engineering practices as reflective to engineering activities, where students are expected to conduct investigation, design models, and find solutions or explanations to a phenomena. Engineering practices have many benefits and reflect on students' learning outcomes, by enhancing the understanding of science, math and the effective use of technology. Marulcu and Barnett (2016) and Krajcik and Delen (2017) believe in the twinning of engineering and scientific practices.

The figure below was suggested by Lesseig, et al. (2016) who had the same belief. He posted the design cycle as a combination of science and engineering practices, starting by asking questions to the final step of adjusting and re-designing.

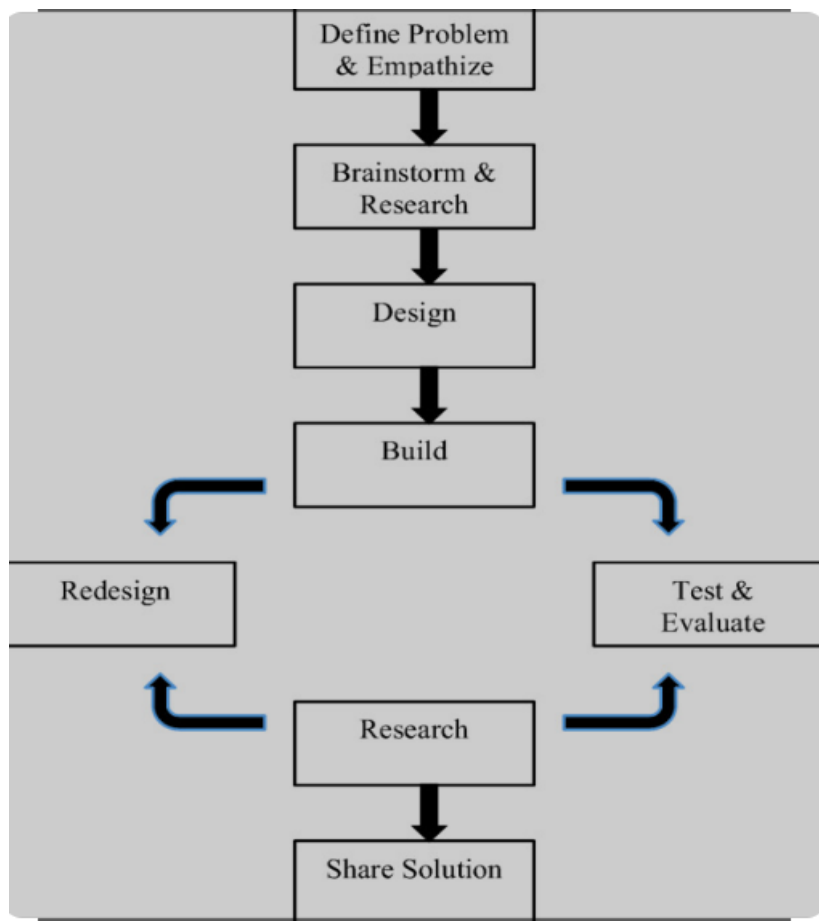


Figure 3: Engineering design process , (Adpoted from Lesseig, et al. 2016)

Based on the NGSS framework, technology is integral part and partner in applying successful NGSS, which combined between knowledge and engineering practices. These

practices could be done using technology and following the engineering design process, as suggested by Lesseig, et al. (2016).

2.2 Literature Review

2.2.1 The UAE and Technology

Over the past few decades, the UAE government invested in developing and improving the country's education. In addition, the UAE opened the door widely for all new technologies that could serve education. Al Murshidi (2019) added that the UAE government, aware of the future of advanced technology, conducted numerous movements for proper preparation through supporting STEM education, the integration of science, technology, mathematics engineering design (Johnson 2013); and artificial intelligence. The UAE integrated technology in teaching instructions and curriculum design, like producing materials and textbooks with online versions. The materials supported students and teachers with customizable presentations and worksheets, yet some teachers found some difficulties in using these online resources (Shaer, Zakzak & Shibl 2019).

The efforts of the UAE to promote digital education were noticeable with the success of online teaching during the COVID-19 pandemic. All schools are equipped with digital platforms and LMS for teaching, learning, monitoring, assessment, and appropriate mentoring when necessary.

Integrating technologies and easy accessibility opened the door for students and ignited their interest. Numerous fields of studies linked or merged with technology in universities were not limited to male students, but were made available also for female students. Surprisingly, as reported by the UAE National News (2018), more women in the UAE and the rest of the Middle East enrolled in science and technology-related programs than in many other countries'. The report stated that 77% of computer science classes in UAE are composed of female students; a significant increase was also reported in the number of female engineers and scientists. Emirati women have joined the workforce as well. Moreover, the International Atomic Energy Agency (IAEA) reported that the number of Female nationals in the nuclear sector has tripled between 2014 and 2015 (The National News, August 2017). During COVID 19, online learning and the usage of all available

technological resources and applications was the only option for teachers or students of both genders. Many researchers highlighted the importance of computational skills for students regardless their genders (Hergüner, et. al. 2021). Veletsianos, et. al., (2021) found that gender did not affect students' learning, but time and space did. On other hand, Perkowski (2012) indicated the difference between gender's performance in distance learning; female students showed better academic performance and self-efficacy while male students were more engaged during the online learning sessions. Both genders showed the same patterns in daily live technology usage (Moussa & Seraphim 2017), but for educational purposes female are more willing to move towards e-learning (Madsen & Cook 2020). The demographic factors have big influence in integrating technology in education, in particular science education. These demographic factors may affect students' college readiness and life careers although some studies believe gender has nothing to do with students' achievements in e-learning or their college choices and decisions (Bernasconi 2017; Price 2010).

Based on the above, the researcher felt prompted to look into the impact of demographics on the interest in science and technology. The demographic aspects or variable (Figure 4) of this study included teachers' gender, qualification, experience, subject they are teaching, and their students' gender.

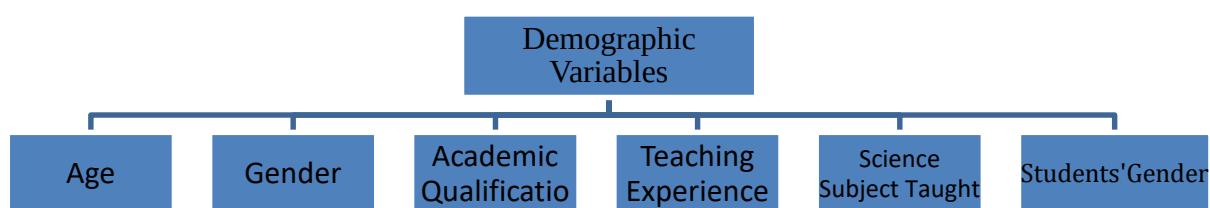


Figure 4: Demographic aspects of the study

Also in the context of the UAE, Saif Alneyadi (2019) conducted a qualitative study aiming at examining teacher's opinions on implementing VLs and their role in promoting more effective science instruction and research in the UAE. With a sample of 45 science teachers coming from 10 schools, the study collected data from a focus group by means of interviews. To guide the work of the study, the interviews included a question about the

frequency of VLs work alongside another question about the intended goals of using VLs. The results of the study indicated that VLs were narrowly and irregularly used. Nevertheless, the results revealed the positive impact of VLs with regard to the knowledge, attitude, skills, and achievement of the students. VLs were also positively significant in enhancing the learners' motivation, academic performance, engagement, and innovation level. Alneyadi (2019) concluded that when it comes to current practices in the use of VLs, it is recommended that the method of implementation, frequency, and scale of VLs need to be maximized to reap more benefits.

2.2.2 Technology and Science Education Pedagogy

Since the days of Galileo and his inclusion of technology in science, many technologies have been developed and been utilized in scientific inquiry. Technology-mediated learning has been a topic of interest in education in recent decades. Bernhard (2018) pointed out that science learning can become meaningful in various aspects such as scientific visualization tools, databases, data collection and analysis tools, computer-based simulations, and modelling. Thus, technology sets science apart from most school subjects. He further highlighted that the role of experimental technologies in learning labs is supposed to be viewed as a material-discursive practice, keeping into account the conditions and technology used apart from computers.

Technology invaded the world rapidly. It aims to help people in industries, health and education, and many other disciplines. Today's generation was born with technology. Generally speaking, today's generation cannot imagine a world without technology. For educators, though, technology is meant to help students do their tasks, carrying out learning outcomes, thus developing their 21st-century skills. Bourdeaux (2017) stated that with the help of technology, all required competencies to succeed in their life and career can be achieved.

Teaching science through hands-on activities or lab experiments was recommended many years ago. Science labs contribute to students' understanding of concepts and developing their skills.

The National Science Teaching Association (NSTA) defined school scientific experiments “as an experience in the laboratory, classroom, or the field that provides students with opportunities to interact directly with natural phenomena or with data collected by others using tools, materials, data collection techniques, and models.” Classes in science laboratories are not random activities from teachers; they should be an integral part of the science curriculum for effective teaching and learning (NSTA 2007).

In real-life scenarios, science laboratories have certain limitations. As mentioned in the introduction of this study, laboratory equipment and activities preparation can be costly. It is also time-consuming in terms of planning and execution. The lack of laboratory equipment also limits a science class in performing even a single simple experiment. It also impacts the science teacher’s evaluation process in a laboratory class, where many students perform experiments simultaneously.

Science education has been served with many technologies; the invention of virtual reality, in particular, has had a remarkable impact. Muhamad, Zaman & Ahmad (2010) stated that virtual science laboratories could enhance and improve the effectiveness of science teaching and learning, resulting in enhancing subject learning. The effect of using virtual laboratory has been very significant. It overcomes obstacles in the traditional laboratory faced during experiments. In short, the use of virtual laboratories helps attain educational objectives (Tüysüz 2010).

2.2.3 Digital Curriculum

The main objective of designing curriculum is to enhance and increase students’ achievements, by mastering all required skills in various subjects (Mullis et al., 2009). Wilson (1997) listed 11 different types of curriculum, starting with design curriculum by teachers and school administration, all the way to the electronic curriculum, defined as any lesson, is it by searching for information or by using any e-forms of communication.

With the rapid digitalization invading education and teaching students as digital natives, curriculum development should be directed towards new technologies, and technologies must be key in educational science instructions. Al-Rsa’i (2013) highlighted how a digital curriculum assesses learning objectives that cannot otherwise be achieved in a regular

curriculum for various reasons. He added that the digital curriculum positively impacted students' attitudes towards science education to understand scientific issues and phenomena.

The new characteristics of the 21st century have brought about massive changes and impacts on science classrooms. The viability of the internet and smart devices amongst students and school resources created new opportunities for learning; these must be reflected as a digital curriculum. The regular curriculum will not match the new era and digitalization, as schools have limited science curriculum, resources, and professional development for their teachers, which, in turn, directly affects students (Seiki, Domínguez & Asato 2021)

During the Covid-19 pandemic, most schools globally shifted to online teaching, with both teachers and students in a completely new situation. The learning process was expected to continue, and the desired learning objectives had to be achieved. In a regular science curriculum, many learning objectives are dependent on conducting regular science laboratories, and the pandemic eliminated this

Distance and online education during the pandemic revealed unquestionably positive results. Digital curriculum can result in seamless learning, and students have adapted to the new learning mode. However, as Mardesci (2020) pointed out, students' learning motivation was also negatively affected due to a shortage of learning resources, including “an ideal curriculum relating to the 21st century competencies and balanced integration of school-subjects and generic competences and skills. For example, the Finnish core curriculum emphasises the ICT literacy skills and their role among other competencies and school subjects” (Thuneberg et al. 2022).

Ananga (2020) observed that students' motivation was affected by the course designs where the deductive approach was implemented. Thus, he suggested that instructional designers consider diverse approaches in chunking learning content. He further reiterated that learning styles need to be considered. E-learning, therefore, should be designed accordingly based on factors like levels of skills and experiences. This approach supports constructivism, which eventually would lead to an appreciation of learning amongst

students. (Paidi 2020) argued that the success of the curriculum is affected with the quality of the learning process, but the dominant factor in effective curriculum implementation remains the teacher. On the other hand, Wicklein (1997) addressed how the potential digital curriculum could provide opportunities for both teachers and students; yet, educators did not show enough seriousness and consistency in designing and implementation of digital curriculum.

Rasinen (2003) concluded in his study that the six countries he investigated are all at different levels of developing their own technological curriculum, with no definite standards for technological curriculum countries and that even cities could be on different levels of technological curriculum evaluation. This has provided rationale for investigating the technological curriculum in Ajman's schools.

2.2.4 Virtual Laboratories

Whether due to the pandemic or during regular teaching mode, science educators have viewed virtual labs as Technological Pedagogical Knowledge (TGK), where students can investigate models and observe different scientific phenomena around them. Virtual laboratories opened the door to many previously impossible investigations irrespective of resources, timing, or location.

Many researchers defined virtual laboratories in different ways. Aljuhani et al. (2018) described virtual laboratories as “an educational environment that uses virtual technology and provides tools and visualizations that motivate the students to participate and collaborate within the class.” Babateen (2011) described virtual laboratories as a studying and learning environment that stimulates the actual lab. It provides the students with tools, materials, and lab sets on the computer to perform experiments individually or within a group anywhere and anytime. These experiments are saved on CDs or a website - “a computer simulation which enables essential functions of laboratory experiments to be carried out on a computer is called a virtual laboratory” (Harms 2000).

Further, Bajpai & Kumar (2015) defined virtual laboratories as computer programs that allow students to run simulated experiments via the web. A virtual lab could be a set of simulations put together (applets, flash base demons, animations, etc.). This allows

students to perform the experiments remotely at any time. Al-Rsa'i (2013) noted that in science teaching, the web-based remote control laboratory is a system that enables students to control actual experiments from a remote location using the internet and a normal web browser.

Different definitions of science virtual laboratory share some keywords that researchers agreed upon. Virtual laboratories can be offline or online, on CD or website and can be performed remotely. Virtual laboratories can mimic actual experiments, where students can carry out science experiments. In addition, as indicated by Radhamani et al. (2021), they can be used either in a blended learning or in a fully remote teaching setting, as was the case during the COVID-19 pandemic. It is important to mention that COVID-19 introduced a new paradigm in science education called “Kuhn paradigm shift” of the new millennium in education. Teachers are required to use more innovative methods in teaching their students and use technological approaches and tools in teaching science (Cerezo, et al. 2021; Aderibigbe, Dias, & Abraham 2021).

2.2.5 Previous Studies of Virtual Laboratories

In recent years, there has been an increase in the literature exploring and investigating virtual laboratories in science education and their impact and effectiveness on science learning.

Restivo et al. (2011) noted that considering the diversity of learning styles and that nothing applies to everybody. Remote laboratories appear as remote access to hands-on activity, offering tools for inductive teaching and learning in the student-centred education and learning method. Kfir (2001) claimed that virtual laboratories now have the floor with significant advancements in the internet and infrastructure; more than this, in some cases, virtual laboratories could be preferred over traditional laboratories. In like manner, Tüysüz (2010) highlighted a noticeable impact of using virtual laboratories in increasing students' achievements and motivation. Virtual laboratories created an interactive and entertainment science lessons environment; yet, he did not claim that virtual laboratories are better than face-to-face laboratories.

The study investigating virtual laboratories in Saudi Arabia conducted by Aljuhani et al. (2018) revealed that virtual laboratories are an excellent method in conducting experiments. The use of virtual laboratories leads to an increase in teaching efficiency, not to mention saving costs. Thus, teaching should always keep up with all evolving technologies.

Tala (2017) added that virtual science laboratories help improve learning methods and provide students with a safe and secure interactive learning environment. Virtual laboratories were also found to be engaging, enjoyable, and practical. Providing students with an excellent opportunity to demonstrate science experiments is safe.

All in all, whether to use virtual or actual laboratories constitutes a decision that needs to be based on the benefits to be reaped in comparison to the shortcomings of the process. Bilek and Skalická (2010) carried out a qualitative study to compare the outcomes of incorporating real and virtual applications in science classes. The majority of chemistry students surveyed preferred hands-on experiments and did not believe virtual applications were a useful way to acquire scientific skills.

Using observation and achievement exams, Tüysüz (2010) investigated the effects of virtual chemistry labs on the success and attitudes of 9th-grade students. Virtual Lab (VL) software had a positive impact on the success, attitudes, and motivation of students, as well as making it easier for them to identify learned topics. The study also noted that VL can act as a stand-in for a real lab when circumstances prevent the latter from being used.

Similarly, Harrison et al (2009) carried out research to explore how VL software affects high school students. Achievement Tests, observations, and interviews were used to obtain data from 464 science students. The findings showed that using virtual chemistry lab software improved the experimental technique scores of students. In addition, it was noted that the VL program assisted them in focusing on the experimental process and completely comprehending the experiment.

Moreover, Gorghiu et al. (2009) investigated the impact of VL software on 7th-grade pupils' understanding of "acid-base and neutral solutions." According to the findings, VL software improved users' satisfaction and efficiency, helped them comprehend theoretical concepts better, and was particularly useful in hypothesis verification as well as boosting

motivation. Students also used VLS to enhance their abilities in a risk-free, practical setting.

A lot of other literature compared natural (traditional laboratories) and virtual laboratories by asking the question as to whether virtual laboratories can replace traditional laboratories or if they were just another supportive technological resource. Some studies listed the advantages and disadvantages of virtual laboratories as well.

Even though many researchers in science education agreed on the fundamentality of laboratories practice in teaching and learning science, many limitations of traditional science laboratories were identified. The limitations affected the success of conducting and achieving the objectives of conventional laboratories. Vincenti, Bucciero, & de Carvalho (2014) pointed out limitations such as time, resource shortage, safety, and operational protocols.

Chudaeva (2021) identified several advantages and reasons why integrating virtual laboratories in science courses. Among the benefits is the ability to create an authentic learning experience, exclusive learning opportunities, the possibility of enhancing students' understanding of scientific methods and principles, promoting creativity and innovation, and finally, anchoring the technology's advanced usage in the learning process.

Ambusaidi et al. (2018) pointed out that the experiments can be designed according to students' needs; the materials can be adapted to their learning needs and environment; the simplicity and complexity can be controlled; the number of variables can be more than in traditional experiments; of the level of safety is higher in comparison to actual classic experiment; and at the end flexibly in time and space.

The fast-paced technological teaching approach in science education and support of using virtual laboratories did not stop to address the concerns of some science educators and researchers. These concerns can be labelled as disadvantages of virtual laboratories (Mikhaylov & Chernov, 2012). The main concern is the reality separation; students may lose out on some technical skills and accuracy, like dealing with specific measurements in chemistry or fixed sectioning in biology. Also, students can miss the supervision of well-educated and experienced science teachers. Another possibility is that technical problems

and the internet bandwidth servers can be down on some days, and not all students have the adequate bandwidth to support the virtual laboratories.

Budai & Kuczmann (2018) also discussed the advantages and disadvantages of virtual laboratories. They saw breaking the limitation of any physical constraints as an important advantage. Virtual laboratories can also be effective in tracking students' information and statistics. In addition, virtual laboratories are safe, thus eliminating risks from students' mistakes while conducting the experiments. However, the lack of seriousness of students towards virtual laboratories and dealing with the experiments as video games may waste the chance of actual contact of 3D models.

Even though most researchers are optimistic about integrating technology in learning, many national and international literature showed a lack of technology integration in education. This lack of integration is attributed to teachers' unwillingness and lack of readiness towards technology literacy. Many teachers openly admit that their technological literacy is not adequate (Sezer 2015). This study shall look into the different factors mentioned above to identify the teachers' perspectives on science virtual laboratories.

CHAPTER 3: Methodology

As discussed, the literature review has shown a lack of studies investigating virtual laboratories of high school schools following the American curriculum, in the UAE. In addition, there are no studies that refer teachers' perceptions and practices with regard to virtual laboratories in UAE schools. This study was carried out in different schools following the American curriculum, in UAE-Ajman, during April, 2022.

Choosing research methodology is crucial for proper data analysis; it keeps focus on the research design and on the progress of data collection. This chapter will introduce and justify the methodology design, the adopted research philosophical paradigm; the instrument used, the participants, as well as how data will be collected and ethical considerations.

The methodology will serve to find answers to the research questions of this study, which aims to investigate high school science teachers' practices and perceptions of science virtual laboratories, and to find the answer for the proposed four questions.

1. What are the aspects of high school science virtual laboratories in UAE?
2. What perceptions do high school science teachers have regarding virtual laboratories in UAE?
3. What practices do high school teachers have regarding virtual laboratories in UAE?
4. What demographic differences, if any, do high school science teachers have regarding their perception of virtual laboratories in UAE?

3.1 Research Design

This section includes the chosen set of procedures to conduct the research. To find the answers to the proposed study questions, mixed design methodology will be followed. Johnson & Onwuegbuzie (2004) defined the mixed research paradigm "as the class of

research, where the researcher mixes or combines quantitative and qualitative research techniques, methods, approaches, concepts or language into a single study.”

Choosing mixed research design will help in answering research questions more broadly, benefitting from each the advantages of each method. In addition, using mixed methodology will enrich numerical data with description, providing enough information and knowledge about the practices and perceptions of teachers.

Gorard (2004) stated that for educational research purposes, using mixed methodology can be fundamental in social science improvement. It can also prevent any loss of useful information. Therefore, qualitative and quantitative methods approaches are an ideal choice of method, as both are considered to complement each other.

The researcher investigated what science teachers think about science virtual labs, and how they use them during science lessons. From this, the research paradigm that resulted is pragmatic, with no definite facts or truths that could be projected on this research. Therefore, to understand and conclude the perceptions and practices of teachers, using a mixed approach is deemed ideal to find the answers to the research questions and provide a wider scope for collected results in both quantitative and qualitative (Johnson 2014). It also opens doors by providing the opportunity to show different views, understanding, and assumptions, so using different methodology and approaches are essential to gain answers and an understanding of the research problem (Creswell 2014).

A pragmatic paradigm provides the researcher with freedom and does not restrict her to limited choices of methods in order to collect data. In the current conditions and restrictions due to COVID-19, using digital means to communicate with participants and for the distribution of the instruments seems suitable. This rationale utilizes the advantages of the chosen approach to the maximum, resulting in increasing the validity and reliability of the results (Creswell 2014).

The researcher mirrors into pragmatism philosophy, where the focus of the research is the outcomes. This requires implementing mixed methodology using different approaches to

gather information in the best way to answer the research questions in depth (Creswell 2014).

This study aims to collect data about teachers' perceptions and practices of virtual science laboratories in the UAE. Teachers are the pillars of this study; their actual beliefs, perceptions and practices are crucial. Using mixed methodology is the main reasoning in executing the research, as it will provide logical models, by using the best of the qualitative and quantitative approaches, and overcoming the limitation of both approaches (Creswell 2014).

The study will rely on the outcomes of schools in Ajman following the American curriculum, by adopting and using mixed methodology, which Creswell (2014) defined as an approach to inquiry that combines or associates both qualitative and quantitative forms.

The research contains several stages in order to obtain the desired data to answer the proposed questions, more specifically explanatory sequential approach. At the first stage, the quantitative approach will be used in order to collect data; the data will be collected from high school science teachers who are teaching biology, chemistry or physics with regard to their perceptions on virtual labs in science lessons. A questionnaire will be shared with the teachers, after which qualitative data will be collected; teachers will answer few open-ended questions for more comprehensive data to answer the research questions.

The quantitative data are the primary data that will guide the study; however, the qualitative data is required as supportive procedures (Creswell 2014). Johnson & Christensen (2012) argued that the combination of different types of data will assist the researcher to provide a broader and full image of the problem of the research by gaining different perspectives.

The figure below represents the stages and steps used to gather data for the study.

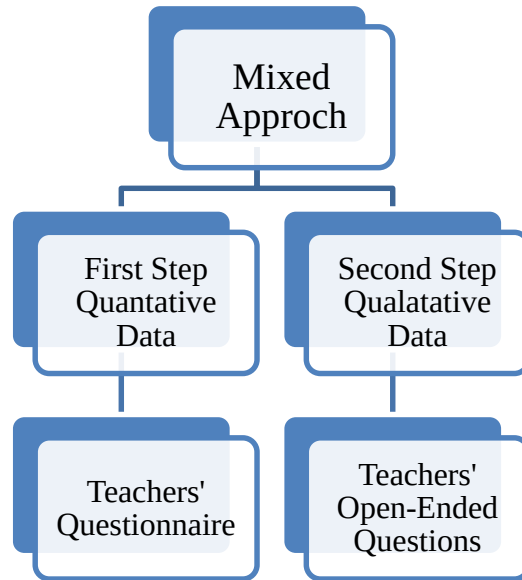


Figure 5: The Research Design of the Study

3.2 Site

The study was conducted in the Emirate of Ajman. The only three schools in Ajman, adopting the American curriculum and offering a high school program were included in the study. The schools are accredited by both the UAE MOE and Cognia (US accreditation organization). This gives validity for the schools as American curriculum schools, which embrace the NGSS of the science curriculum design.

The NGSS were designed to equip the next generation with essential skills through integrating science and technology. They include eight practices, requiring students to use engineering and technological approaches, such as using computational thinking to understand and solve problems in their daily life situations. In addition, NGSS include STEM lessons (Science, Technology, Engineering, and Math).

NGSS support innovative approaches in teaching science, in particular, technology integration to help students to pursue their future careers (Copp, Isaacs & Hespanha 2021). Schools worldwide executing NGSS, including UAE-based schools following American educational program, have the obligation to integrate technology in science pedagogy

approaches. The above considerations allowed the researcher to formulate a rationale for choosing these schools to participate in this study.

3.3 Study Procedure

To enable the collection and processing of the desired data from the targeted sample, the study involved various stages.

This study aimed to investigate teachers of high school science subjects and perceptions in Ajman schools administering American curriculum.

The following steps were followed in this study.

1. Creating and developing the instrumentation tool.
2. Identifying key information about the number of schools in Ajman and collecting some general information by calling the schools and visiting their websites and social media accounts.
3. Three schools in Ajman follow the American curriculum from K-12. The rest of the schools either follow other curriculum programs, or if they are following American system, they are limited to certain grades.
4. The questionnaire was shared with targeted participants.
5. The participants were provided with all required information about the aims of this questionnaire, why it is important to administer it, assuring their confidentiality, and, finally, making them aware of the time framework.
6. A reminder was sent to remind participants and encourage them to complete the questionnaire.
7. Collecting the data (quantitative and qualitative) .
8. Data analysis.
9. Reporting and discussing data.

3.4 Sampling and Participants

Mertens (2010) defined a study population as a complete set of elements that shares and contains analogous characteristics of the proposed sampling criteria.

The population of this study is any high school teacher, currently teaching physics, chemistry or biology in any school following the American educational program based in Ajman-UAE, these conditions applied only on three schools in Ajman the average number of teachers in the three schools are 30 teachers, Fraenkel & Wallen (2012 p. 97) called this sample 'accessible population' as part of the whole target population the researcher can easily have access to.

The accessible population of this research is a group of high school science teachers of grades 9-12, teaching biology, chemistry and physics in three American curriculum schools based in Ajman-UAE.

The researcher will be able to reach a presentable sample, which can be defined as the group of actual individuals who will take part in the research; those individuals are derived from the research target population (Bhardwaj 2019). Kibuacha (2021) defined sampling as "a method that allows researchers to infer information about a population based on results from a subset of the population, without having to investigate every individual. Reducing the number of individuals in a study reduces the cost and workload, and may make it easier to obtain high quality information." However, the total population of this study is consider to be small, with less than ($N = 30$) high school science teachers in three American curriculum schools.

The sample chosen to this study is selected purposefully, as all participant teachers are high school science teachers, currently working in accredited schools in Ajman following American educational program.

3.5 Instrumentation

The study is based on a mixed methodology approach, which led to using more than one instrument to collect data. Fraenkel & Wallen (2012, p. 118) defined instrumentation as "the whole process of preparing to collect data; it involves not only the selection or design of the instruments, but also the procedures and the conditions under which the instruments will be administrated."

The first instrument in this research is high school science teachers' questionnaire, followed by open-ended questions to be answered by high school science teachers. At the end of the process, the data will be collected and analysed to provide a clear picture of the perceptions of high science teachers towards virtual laboratories in science classes in Ajman.

A questionnaire is an ideal tool for its advantages in collecting written responses (Fraenkel & Wallen 2012, p. 122). In social sciences questionnaires, are among the best desirable options in collecting information (Goddard & Villanova, 2006; Rumrill, Cook & Wiley (2011). In addition, Johnson & Christensen (2012) defined questionnaire as "a self-report data-collection instrument that each research participant fills out as part of a research study." Also, Munn & Drever (1989) listed the main four advantages of questionnaire instrumentation in collecting data;

1. Time saving
2. Anonymous, as participants' identity can be kept confidential
3. High chances of responses
4. Standardized questions

McMillan & Schumacher (2010) added that a questionnaire is a preferable and helpful tool in collecting data in uniformity, side by side with confidentiality and ease in use for both participants and researcher.

The questionnaire of this design is usually created to collect quantitative data; they can be administered in many different settings, paper based or online. This study's questionnaire was designed using Google forms to collect responses online, using the advantages of an online setting that include facilitating reaching people, saving time and cost, in addition to giving the space, time and comfort for participants to complete the given questionnaires.

On the other hand, setting questionnaires online can provide privacy to participants, as questionnaires can be completed anonymously. This encourages participants to share their

experiences, practices and perceptions (Goegan, Radil & Daniels 2018; Kalkbrenner 2021).

The questionnaire of the current study contains four sections to cover the scopes of the study, namely the practices and perceptions of high school science teachers. The first section deals with teachers' demographic information. It includes nine questions, starting with confirming city and curriculum taught, then followed with questions to easily group and categorize respondents according to nationality, gender, age, academic qualifications, years of experience, subjects taught, and, finally, the gender of the current students.

The second part contains eleven questions about virtual laboratories curriculum, and the third part contains twenty three questions about science teachers' practices and perceptions of virtual laboratories.

Both sections two and three contain closed-questions designed based on a Likert scale (5-point scale) to indicate teachers' agreement or disagreement. Likert scaling is particularly appropriate for measuring attitudinal constructs (e.g., personality, beliefs, values, or emotions) (Kalkbrenner 2021). A Likert scale helps participants to place their thoughts, beliefs, practices and perceptions (Goegan, Radil & Daniels 2018).

The fourth section includes open-ended questions; by adding this section, the questionnaire will be labelled as a mixed questionnaire. This is considered a favourable approach, as open-ended questions can overcome some limitations of closed questions, especially that closed questions can limit participants in expressing their feelings or using their own words (Goegan, Radil & Daniels 2018). Moreover, gaining qualitative data will also help the researcher in clearing any vague areas that could be difficult to understand using quantitative data.(Appendix 2)

Table 1: Research instrumentation (questionnaire) constructions

	Aims	Method of Response	Type of Date Collected
Part 1	Teachers Demographic Information	Self-select-responses	Quantitative

Part 2	Virtual Laboratories Curriculum	Likert Scale	Quantitative
Part 3	Virtual Laboratories Practices and Perceptions	Likert Scale	Quantitative
Part 4	Virtual Laboratories Practices and Perceptions-Teachers' explanation	Open-ended questions	Qualitative

Participant teachers were asked to complete the questionnaire within two weeks, after receiving it through email. Teachers received a reminder after one week to encourage them to complete the questionnaire within the given deadline and increase the number of participating teachers.

3.6 Validity and Reliability of Study

After identifying the study aims and questions, the questionnaire was created and developed in order to collect sufficient data to answer the research questions about teachers' perceptions and practices of virtual laboratories in science lessons.

To construct the validity of the instrument, the researcher created the questionnaire after looking at similar instruments in similar studies. The instrument was reviewed by two science educators and one university instructor holding PHD in education in one of UAE universities. Next, the instrument was shared with the researcher's supervisor, who gave notes and suggestions to improve the instrument. The final step was sharing the instrument with approval committee for final review and approval. In addition, choosing mixed methodology by using both quantitative and qualitative approaches for data collection was beneficial to enhance the credibility of the study findings (Johnson & Onwuegbuzie 2004).

It was useful to pre-test the instruments to ensure the reliability and clear any ambiguities. To that end, the questionnaire was shared with seven science teachers teaching elementary and middle school to test the instrument's reliability.

The level of reliability of teachers' questionnaire was measured using SPSS and resulted in a Cronbach's-Alpha equal to 0.992, which is considered a significantly high level of consistency for 40 questions.

Table 2: Reliability Statistics of Teachers' Questionnaire

Cronbach's Alpha	0.992
Number of Questions	40

At the end, study design feasibility is based on school information and gives the researcher the ability to fully use two different methods in one study (Creswell 2008).

3.7 Data Analysis

Upon the completion of the steps of the study, the data collected went through several stages of analysis in order to obtain all the required information to answer the research questions.

The researcher started the analysis with quantitative data; SPSS software was used to analyse quantitative data. Next, the qualitative data were analysed to support the results.

Forms for collecting quantitative data were shared with teachers through Google forms. The questions were designed in form of a five-point Likert scale. At the end of the study timeline, the data was extracted into an excel sheet and then statistically analysed using SPSS.

The data was first analysed in relation to demographic information, and then in matter of different variables. The analysed data is presented in graphs and tables to show the results.

As for qualitative data, responses collected from teachers to four open-ended questions were analysed based on themes. The responses collected from the open-ended questions were classified into core themes. Thematic analysis is a very popular and widely spread method used in analysing results driven from qualitative data (Kiger & Varpio 2020). It is effective and useful for most research objectives and theoretical perceptions (Clarke & Braun 2013). Qualitative data collection methods are exploratory, and they are usually focused on gaining insights and understanding the underlying reasons by digging deeper. Due to the lack of measurability, qualitative data collection methods are primarily

unstructured. The core themes were reviewed by another researcher to ensure reliability and accuracy (Creswell 2014).

3.8 Ethical Considerations

The purpose of this research is to investigate the perceptions and practices of high school science teachers towards virtual laboratories. This main focus of the study was clearly introduced and explained to all participants.

The data collected could help in improving technological integration with science education in Ajman, resulting in possible positive impact on students' achievements in science subjects.

Bryman & Bell (2011) highlighted the importance of considering ethical issues when conducting research, while Gajjar (2013) stressed how crucial the consideration of ethical standards in research validation is. In addition, Punch (2005) reiterated that it was crucial to anticipate and actively address any ethical concerns that may arise during the study.

On the other hand, Creswell (2014) stated the five ethical principles of any research, underscoring fidelity and responsibility, integrity, justice, and respect for people's rights and dignity. In her pursuit to achieve the goals of the study, the researcher took into consideration these principles and followed the BUID's ethics protocol to evaluate the level of risk of the study. Eventually, the study was evaluated as low risk.(Appendix 1)

The procedure and instrumentation followed assure participants' confidentiality and anonymity, so is school information. Further, no comparison between schools will be performed, as the data will refer to American schools in Ajman as a single unit.

Chapter 4: Data Analysis and Results

This current study aims to investigate high school science teachers' perceptions and practices of virtual laboratories in private schools following the American curriculum in Ajman-UAE.

This chapter presents the outcomes of both quantitative and qualitative instruments used to investigate teachers' perceptions and practices, as well as teachers' responses to open-ended questions.

4.1 Demographic Information

The study targeted high school science teachers, who teach biology, chemistry or physics to grades 9-12, in Ajman schools following the American curriculum.

The first part aimed to collect demographic information, including nationality, gender, age, academic qualification, teaching experience, science subject taught, and their students' gender.

4.1.1 Nationalities

The responses came from teachers from eleven different nationalities.

Table 3: Teachers' Nationalities

Nationality	Percentage
Algerian	3.7 %
Pakistani	14.8 %
Jordanian	18.5%
Philippine	7.4%

Iraqi	3.7%
Indian	3.7%
Nigerian	3.7 %
Palestinian	7.4%
Sudanese	3.7 %
Egyptian	3.7 %
Lebanese	3.7 %

4.1.2 Gender

The below table shows the distribution of teachers participating in the study in terms of gender.

Table 4: Teachers' Gender

Gender	Male	48.1 %
	Female	51.9 %

4.1.3 Teachers' Age

With regard to the participating teachers' age, all teachers were below 60 years old, with almost half (48%) between 31 and 40 years old.

Table 5: Teachers' Age

20-30	11.1 %
31-40	48.1 %
41-50	33.3 %
51-60	7.4 %
Above 60	0 %

4.1.4 Academic Qualification

The teachers' academic qualifications included bachelor's degrees, master's and doctorate degrees, with more than half (55%) holding a bachelor's degree.

Table 6: Teachers' Academic Qualification

Diploma	0 %
Bachelor's Degree	55.6 %
Master's Degree	40.7 %
Doctorate	3.7 %

4.1.5 Teaching Experience

Next point to consider in the collected data was the teachers' teaching experience as shown in the table below.

Table 7: Teachers' Teaching Experience

1-5 Years of Experience	14.8 %
6-10 Years of Experience	40.7 %
11-15 Years of Experience	25.9 %
16-20 Years of Experience	7.4 %
More than 20 Years of Experience	11.1 %

4.1.6 Science Subject Taught

The table below shows the distribution of participating teachers according to the science subject they teach.

Table 8 : Science Subject Taught

Physics	22.2 %
Chemistry	29.6 %
Biology	48.1 %

Table 9: Science Students' Gender

4.1.7 Gender of current students

Male	63%
Female	37%

4.2 Quantitative Data Results

In this section, the researcher will show the results of the quantitative data collected, and present them in response to different variables.

The first part will introduce the questionnaire responses for all questions, the second part will include teachers' responses to virtual laboratories science curriculum, and the third will analyse teachers' practices and response towards virtual laboratories in their science classes. Both the second and third parts will also compare male and female, science subjects taught, students' gender, teachers' qualifications, and teachers' experience.

4.2.1 Questionnaire Responses

The table below contains the whole perceptions results of the questionnaire shared with high school science teachers. The Table 10 shows that the minimum score was between 1 and 4, and the maximum score was between 4 and 5, with the standard deviations overall less than 1. This, in general, indicates that teachers' choices are close to the mean results.

Teachers' perception of curriculum integration was the highest with lowest 4 and highest 5. That indicates that teachers believe in the importance of successful curriculum planning to

enhance their knowledge. However, teachers did not share perception when it comes to virtual laboratories safety in comparison to traditional labs; the lowest was 1 and the highest was 5, the mean between the highest and the lowest perceptions can indicate teachers have shared perceptions in some areas and are different in other ones.

Table 10: Survey Results with Standard deviation (Descriptive Statistics)

	N	Minimum	Maximum	Mean	Std. Deviation
1. I include virtual laboratories when planning for lessons and instruction.	27	3	5	4.41	0.572
2. The curriculum integrated with virtual labs has helped building knowledge in my content area.	27	4	5	4.37	0.492
3. The curriculum I teach includes virtual laboratories designed to reach all students.	27	2	5	4.07	0.917
4. The curriculum contains virtual lab that helps my students to learn.	27	3	5	4.44	0.641
5. The information and display of the curriculum is easy to use	27	3	5	4.00	0.620
6. The curriculum design has all the information you need and is accessible	27	2	5	3.85	0.602
7. I am confident in teaching curriculum integrated with virtual labs.	27	3	5	4.41	0.636
8. I have a system in planning lessons that can work for me.	27	3	5	4.22	0.641
9. I have enough time to prepare science lessons incorporating virtual labs.	27	2	5	3.78	0.751
10. I receive training on curriculum planning and mentoring .	27	2	5	3.81	0.834
11. Virtual mode should be considered when designing curriculum.	27	3	5	4.11	0.698
12. Technology has positive impact on students' learning	27	2	5	4.41	0.747
13. It is easy to prepare lessons with virtual laboratories	27	2	5	3.96	0.808
14. Virtual laboratories are a valuable educational tool.	27	2	5	4.07	0.730
15. Science classes with virtual laboratories are enjoyable.	27	3	5	4.41	0.694
16. Virtual laboratories increase students achievements	27	2	5	3.96	0.706
17. Virtual laboratories increase students engagement	27	2	5	4.22	0.847

18.I am confident in using virtual laboratories in science classes	27	2	5	4.30	0.775
19. Virtual laboratories are safer compared to traditional laboratories.	27	1	5	4.00	1.038
20. Virtual labs can save more time than traditional labs.	27	2	5	3.96	0.854
21. During a virtual lab, you are able to monitor students' progress.	27	2	5	3.56	0.801
22. Students are more responsible of their learning during virtual laboratories.	27	2	5	3.59	0.844
23. Virtual laboratories help in improving students' critical and creative thinking skills	27	2	5	4.00	0.679
24. Students have positive attitudes towards virtual laboratories	27	2	5	3.85	0.770
25. Using virtual labs in my lesson can help me to achieve my lesson's objectives just like if I used traditional labs	27	2	5	3.52	0.753
26. Virtual laboratories can help alongside traditional laboratories in achieving learning outcomes.	27	2	5	4.11	0.698
27. Virtual laboratories are an effective mode of teaching.	27	2	5	3.96	0.759
28. Virtual laboratories affected my role as teacher positively.	27	2	5	3.89	0.751
29. School infrastructure supports the implementation of virtual laboratories.	27	1	5	3.78	0.974
30. Students have their devices (iPads, tablets, laptops, mobile,etc.) during science class.	27	2	5	4.11	0.847
31. The type of technological device students have during science classes can affect the efficiency of virtual laboratories.	27	2	5	3.89	0.934
32. My school provides me with efficient virtual laboratories resources	27	2	5	3.52	0.893
33. I search for free virtual laboratories to use in my science lessons.	27	2	5	4.33	0.832
34. I receive training on virtual laboratories on a regular basis.	27	1	4	2.78	0.751
Valid N (listwise)	27				

4.2.2 Curriculum Responses

This section contains an analysis of teachers' response against virtual laboratories curriculum aspects. The first table shows a comparison between teachers' responses against curriculum questions.

Table 11: Virtual Laboratories Curriculum Descriptive Statistics –Comparison between Males and Females

Virtual Laboratories Curriculum Descriptive Statistics –Comparison Between Males and Females				
	Male		Female	
	Mean	Scale in Words	Mean	Scale in Words
1. I include virtual laboratories when planning for lessons and instruction.	4.38	Strongly Agree	4.43	Strongly Agree
2. The curriculum integrated with virtual labs has helped building knowledge in my content area.	4.38	Strongly Agree	4.36	Strongly Agree
3. The curriculum I teach includes virtual laboratories designed to reach all students.	4.15	Agree	4.00	Agree
4. The curriculum contains virtual lab that helps my students to learn.	4.62	Strongly Agree	4.36	Strongly Agree
5. The information and display of the curriculum is easy to use	4.23	Strongly Agree	3.93	Agree
6. The curriculum design has all the information you need and is accessible	3.92	Agree	3.79	Agree
7. I am confident in teaching curriculum integrated with virtual labs.	4.31	Strongly Agree	4.57	Strongly Agree
8. I have a system in planning lessons that can work for me.	4.23	Strongly Agree	4.29	Strongly Agree
9. I have enough time to prepare science lessons incorporating virtual labs.	3.62	Agree	3.93	Agree
10. I receive training on curriculum planning and mentoring.	3.69	Agree	4.00	Agree
11. Virtual mode should be considered when designing curriculum.	4.08	Agree	4.36	Strongly Agree

The second table presents the differences in teachers' readiness and acceptance towards virtual laboratories curriculum across different science subjects

Table 12: Virtual laboratories Curriculum Descriptive Statistics –Comparison Between Different Science Subjects (Physics, Chemistry, Biology)

Virtual laboratories Curriculum Descriptive Statistics –Comparison Across Different Science Subjects (Physics, Chemistry, Biology)						
	Physics		Chemistry		Biology	
	Mean	Scale in Words	Mean	Scale in Words	Mean	Scale in Words
1. I include virtual laboratories when planning for lessons and instruction.	4.33	Strongly Agree	4.38	Strongly Agree	4.46	Strongly Agree
2. The curriculum integrated with virtual labs has helped building knowledge in my content area.	4.17	Agree	4.50	Strongly Agree	4.38	Strongly Agree
3. The curriculum I teach includes virtual laboratories designed to reach all students.	4.00	Agree	4.13	Agree	4.08	Agree
4. The curriculum contains virtual lab that helps my students to learn.	4.50	Strongly Agree	4.75	Strongly Agree	4.31	Strongly Agree
5. The information and display of the curriculum is easy to use	4.17	Agree	4.13	Agree	4.00	Agree
6. The curriculum design has all the information you need and is accessible	3.83	Agree	3.88	Agree	3.85	Agree
7. I am confident in teaching curriculum integrated with virtual labs.	4.50	Strongly Agree	4.50	Strongly Agree	4.38	Strongly Agree
8. I have a system in planning lessons that can work for me.	4.17	Agree	4.63	Strongly Agree	4.08	Agree
9. I have enough time to prepare science lessons incorporating virtual labs.	3.83	Agree	3.75	Agree	3.77	Agree
10. I receive training on curriculum planning and mentoring.	3.83	Agree	3.88	Agree	3.85	Agree
11. Virtual mode should be considered when designing curriculum.	4.17	Agree	4.25	Strongly Agree	4.23	Strongly Agree

The third table compares teachers' academic qualifications and their effect on teachers' responses towards virtual laboratories in science lessons.

Table 13: Virtual laboratories Curriculum Descriptive Statistics –Comparison Between Teachers' Academic Qualification

Virtual laboratories Curriculum Descriptive Statistics –Comparison Between Teachers' Academic Qualification						
	Bachelor		Master		Decorate	
	Mean	Scale in Words	Mean	Scale in Words	Mean	Scale in Words
1. I include virtual laboratories when planning for lessons and instruction.	4.40	Strongly Agree	4.45	Strongly Agree	4.00	Agree
2. The curriculum integrated with virtual labs has helped building knowledge in my content area.	4.47	Strongly Agree	4.27	Strongly Agree	4.00	Agree
3. The curriculum I teach includes virtual laboratories designed to reach all students.	3.87	Agree	4.36	Strongly Agree	4.00	Agree
4. The curriculum contains virtual lab that helps my students to learn.	4.40	Strongly Agree	4.64	Strongly Agree	4.00	Agree
5. The information and display of the curriculum is easy to use	3.93	Agree	4.27	Strongly Agree	4.00	Agree
6. The curriculum design has all the information you need and is accessible	3.80	Agree	3.91	Agree	4.00	Agree
7. I am confident in teaching curriculum integrated with virtual labs.	4.20	Agree	4.73	Strongly Agree	5.00	Strongly Agree
8. I have a system in planning lessons that can work for me.	4.33	Strongly Agree	4.18	Agree	4.00	Agree
9. I have enough time to prepare science lessons incorporating virtual labs.	3.67	Agree	3.91	Agree	4.00	Agree
10. I receive training on curriculum planning and mentoring.	3.53	Agree	4.27	Strongly Agree	4.00	Agree
11. Virtual mode should be considered when designing curriculum.	4.13	Agree	4.36	Strongly Agree	4.00	Agree

The last table in this section summarizes the comparison between the three main variables across teachers' responses to virtual laboratories curriculum. The numbers show no differences in teachers' response based on their gender; both males and females had the same perceptions and practices towards the curriculum. Regarding the subject taught, physics and biology were closer in their responses, but in case of chemistry the mean was higher. On the other hand, teachers with a master's degree had higher mean responses in comparison to teachers with a bachelor's degree; only one response with a doctorate degree was collected.

Table 14: Summarized comparison across three variables

Variables		Overall Mean	Standard Deviation	Scale in Words
Gender	Male	4.1469	0.49867	Agree
	Female	4.1818	0.35299	Agree
Subject Taught	Physics	4.1364	0.46975	Agree
	Chemistry	4.2500	0.53175	Strongly Agree
	Biology	4.1259	0.34724	Agree
Academic Qualifications	Bachelor	4.0667	0.48039	Agree
	Master	4.3058	0.31824	Strongly Agree
	Doctorate	4.0909	0.0	Agree

4.2.3 Teachers' Practices and Perception

This section presents the analysis of collected data measuring teachers' practices and perceptions towards virtual laboratories in science lesson. It depicts the mean of collected results, and it sheds light on the effect of different variables on the results.

Table 15: Virtual Laboratories Perceptions Descriptive Statistics

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation

1. I include virtual laboratories when planning for lessons and instruction.	27	3	5	4.41	0.572
13. It is easy to prepare lessons with virtual laboratories	27	2	5	3.96	0.808
14. Virtual laboratories are a valuable educational tool.	27	2	5	4.07	0.730
15. Science classes with virtual laboratories are enjoyable.	27	3	5	4.41	0.694
18.I am confident in using virtual laboratories in science classes	27	2	5	4.30	0.775
19. Virtual laboratories are safer compared to traditional laboratories.	27	1	5	4.00	1.038
20. Virtual labs can save more time than traditional labs.	27	2	5	3.96	0.854
21. During a virtual lab, you are able to monitor students' progress.	27	2	5	3.56	0.801
25. Using virtual lab in my lesson can help me in achieving my lesson's objectives like if I used traditional lab.	27	2	5	3.52	0.753
26. Virtual laboratories can help in line with traditional laboratories in achieving learning outcomes.	27	2	5	4.11	0.698
27. Virtual laboratories are effective mode of teaching.	27	2	5	3.96	0.759
28. Virtual laboratories affected my role as teacher positively.	27	2	5	3.89	0.751

Teachers gave responses to 24 questions, which covered different areas. The first part covered how confident teachers are in conducting virtual laboratories in high school science classes, and how they evaluate them as an effective tool in teaching science subjects.

This section will focus on how smooth including virtual laboratories in science lessons has been, whether the teachers are confident in planning these lessons, if they help mentor the students or achieving their learning objectives, and finally if they think it is an effective mode of teaching.

The analysis will be introduced with comparison to different variables.

Table 16: Summary Comparisons of Teachers' perceptions in response to different variables

Variables		Overall Mean	Standard Deviation	Scale in Words
Gender	Male	3.9650	0.68186	Agree

	Female	4.0065	0.41194	Agree
Academic Qualification	Bachelor	3.9515	0.70574	Agree
	Mater	4.0826	0.24547	Agree
	Doctorate	3.8000	0.000	Agree
Teaching Experience	1-5Years of Experience	3.7273	1.17363	Agree
	6-10Years of Experience	3.9091	0.34015	Agree
	11-15 Years of Experience	4.1429	0.26689	Agree
	16-20Yearsof Experience	3.9091	0.64282	Agree
	More than 20 Years of Experience	4.4242	0.50069	Strongly Agree
Science Subject Taught	Physics	4.0758	0.36098	Agree
	Chemistry	4.1818	0.46861	Agree
	Biology	3.8531	0.64233	Agree
Students Gender	Male	3.9840	0.66201	Agree
	Female	4.0273	0.27790	Agree

Here, the questions checked teachers' perception of the effect of virtual laboratories of high school science students, and how they react during virtual laboratories lessons. The questions explored if virtual laboratories have a positive impact over students' learning, help them in increasing their achievements, facilitate their engagement, improve their learning skills, and whether virtual laboratories have positive impact on the students' attitude.

The first table shows the mean average of general responses and standard deviation; meanwhile, the second table contains the overall mean across different variables.

Table 17: Teachers' Perceptions of the effect of Virtual labs on students in science lessons

Question	Mean Average	Standard Deviation
Technology has positive impact on students' learning	4.41	0.747
Virtual laboratories increase students achievements	3.96	0.706
Virtual laboratories increase students engagement	4.22	0.847
Students are more responsible of their learning during virtual laboratories.	3.59	0.844
Virtual laboratories help in improving students' critical and creative thinking skills	4.00	0.679
Students have positive attitudes towards virtual laboratories	3.85	0.770

Table 18: Summary comparison of teachers' perceptions of the effect of Virtual labs on students in science lessons in response to different variables

Variables		Overall Mean	Standard Deviation	Scale in Words
Gender	Male	3.8615	0.63448	Agree
	Female	3.8857	0.42762	Agree
Academic Qualification	Bachelor	3.9778	0.77630	Agree
	Mater	4.0455	0.27979	Agree
	Doctorate	4.0000	0.000	Agree
Teaching Experience	1-5 Years of Experience	3.7917	1.21240	Agree
	6-10 Years of Experience	3.8788	0.42224	Agree
	11-15 Years of Experience	4.2222	0.49065	Strongly Agree
	16-20 Years of Experience	4.1667	0.23570	Agree
	More than 20 Years of Experience	4.1667	0.72648	Agree
Science Subject Taught	Physics	4.1667	0.47140	Agree
	Chemistry	4.2500	0.38832	Strongly Agree
	Biology	3.7436	0.67225	Agree
Students Gender	Male	4.0686	0.69237	Agree
	Female	3.9000	0.39441	Agree

In the last part of this analysis, the focus is on infrastructure, internet connectivity, technological resources and if they receive any regular and proper training. It highlights the school's readiness, how supportive they are in enhancing the use of virtual laboratories from the teachers perceptions, and how could these affect their practices in conducting virtual laboratories in high school science lessons.

The tables below shows the mean of the response and standard deviation, as well as the overall mean in comparison to different variables

Table 19 :Teachers' Perceptions of availability of resources

Question	Mean Average	Standard Deviation
School infrastructure supports the implementation of virtual laboratories.	3.78	0.974
Students have their devices (iPads, tablets, laptops, mobiles, etc.) during science class.	4.11	0.847
The type of technological device students have during science classes can affect the efficiency of virtual laboratories.	3.89	0.934
My school provides me with efficient virtual laboratories resources	3.52	0.893
I search for free virtual laboratories to use in my science lessons.	4.33	0.832
I receive training on virtual laboratories on a regular basis.	2.78	0.751

Table 20: Summary comparison of teachers' perceptions of the of availability of resources

Variables		Overall Mean	Standard Deviation	Scale in Words
Gender	Male	3.6795	0.69543	Agree
	Female	3.7738	0.40619	Agree
Academic Qualification	Bachelor	3.5333	0.64611	Agree
	Mater	3.9091	0.44947	Agree
	Doctorate	3.6667		Agree

Teaching Experience	1-5 Years of Experience	3.4583	0.98484	Agree
	6-10 Years of Experience	3.6364	0.53134	Agree
	11-15 Years of Experience	3.6429	0.49468	Agree
	16-20 Years of Experience	4.1667	0.70711	Agree
	More than 20 Years of Experience	4.0000	0.16667	Agree
Science Subject Taught	Physics	3.8333	0.48305	Agree
	Chemistry	3.8958	0.47088	Agree
	Biology	3.5000	0.65263	Agree
Students Gender	Male	3.6471	0.65054	Agree
	Female	3.7667	0.45947	Agree

Table 20,21,22 and 23 shed the light on the gained information of gender, teachers qualification, experience and taught subjects in relation to curriculum aspects, teachers perceptions and practices, students achievements and resources by ANOVA , Which reveals that P values were insignificant in all the questions in relation to teachers' academic qualifications, and teachers gender, In case of taught subjects ,it was significant on the section of the effect of virtual laboratories on students achievements and the provided resources by school P values >0.05, on contrast to teachers experience P value was significant in both curriculum aspect and teachers perceptions and practices.

Table 21: Teachers' responses according to their gender-On way ANOVA

		SS	df	MS	F	P-value
Curriculum Aspects	Between Groups	0.007641	1	0.007641	0.096665	0.759087
	Within Groups	1.580909	20	0.079045		
	Total	1.58855	21			
Teachers' Perceptions and Practices	Between Groups	0.013605	1	0.013605	0.109062	0.744339
	Within Groups	2.744495	22	0.12475		
	Total	2.758101	23			
Students' Achievements	Between Groups	0.036834	1	0.036834	0.427168	0.528124
	Within Groups	0.86228	10	0.086228		
	Total	0.899114	11			

Resources	Between Groups	0.001834	1	0.001834	0.006681	0.93647
	Within Groups	2.745265	10	0.274527		
	Total	2.747099	11			

Table 22: Teachers' responses according to their academic qualification -On way Anova

		<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>
Curriculum Aspects	Between Groups	0.37757	2	0.188785	2.169759	0.131797
	Within Groups	2.610218	30	0.087007		
	Total	2.987788	32			
Teachers' Perceptions and Practices	Between Groups	1.545473	2	0.772736	1.548739	0.227568
	Within Groups	16.46521	33	0.498946		
	Total	18.01068	35			
Students' Achievements	Between Groups	0.01428	2	0.00714	0.037386	0.963394
	Within Groups	2.864751	15	0.190983		
	Total	2.879031	17			
Resources	Between Groups	0.435482	2	0.217741	0.768632	0.481068
	Within Groups	4.249256	15	0.283284		
	Total	4.684738	17			

Table 23: Teachers' responses according to their Taught subjects- On way Anova

		<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>
Curriculum Aspects	Between Groups	0.108564	2	0.054282	0.714257	0.497692
	Within Groups	2.279927	30	0.075998		
	Total	2.388491	32			
Teachers' Perceptions and Practices	Between Groups	0.536045	2	0.268022	2.668049	0.084324
	Within Groups	3.315057	33	0.100456		
	Total	3.851102	35			
Students' Achievements	Between Groups	1.047841	2	0.52392	5.42199	0.016904
	Within Groups	1.449432	15	0.096629		

	Total	2.497273	17			
Resources	Between Groups	3.80919	2	1.904595	13.45278	0.00045
	Within Groups	2.123644	15	0.141576		
	Total	5.932834	17			

Table 24: Teachers' responses according to their Teachers' Experience On way Anova

		<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>
<i>Curriculum Aspects</i>	Between Groups	2.86831	4	0.717078	4.938315	0.001788
	Within Groups	7.98638	55	0.145207		
	Total	10.85469	59			
<i>Teachers' Perceptions and Practices</i>	Between Groups	2.794179	4	0.698545	4.678358	0.002538
	Within Groups	8.212276	55	0.149314		
	Total	11.00645	59			
<i>Students' Achievements</i>	Between Groups	0.954329	4	0.238582	1.877164	0.145847
	Within Groups	3.177429	25	0.127097		
	Total	4.131758	29			
Resources	Between Groups	2.044899	4	0.511225	1.503099	0.23148
	Within Groups	8.502846	25	0.340114		
	Total	10.54774	29			

4.3 Qualitative Data

The second part of the teachers' questionnaire included open-ended questions; these questions were added to collect some qualitative data to support the quantitative data and provided extended explanation. These questions also provided open window for the teachers to share their perceptions.

The open-ended questions part included four questions, the first of which was to define virtual laboratories. The second question was to draw on their opinion of the effectiveness of virtual laboratories in teaching high school science content. The third question was “What are the difficulties of using virtual laboratories in science lessons?” Finally, the last question asked for input on how to improve virtual laboratories practices in science lessons.

In their responses to the first question, many teachers showed clear understanding by defining virtual laboratories. All teachers were aware that virtual laboratories are conducted digitally.

Virtual laboratory is a media that can provide direct experimental visualizations, interactive virtual environment, and practical experimentation, to do experiments more efficiently, and be able to save on purchasing experimental tools.

Virtual labs are interactive, digital simulations of activities that typically take place in physical laboratory settings and it is done on students' devices.

Yet many teachers stress the point that virtual laboratories are always online.

It is a form on online simulations techniques.

Virtual labs are online interactive resources

It is an online simulation of an actual lab

One response came with wrong explanation; the definition did not indicate any key word of virtual laboratories definition.

The second question: *To what extent do you think virtual laboratories are effective in teaching high school science content? Explain*

The majority of teachers agreed on the effectiveness of using virtual laboratories in teaching science; they believed virtual laboratories can enhance students' competences. Further, most teachers highlighted that virtual laboratories are very effective in filling the gaps and overcoming the disadvantages of traditional virtual laboratories, such as lack of

resources, safety measurements, timeline, in addition to offering the opportunity for repeating the virtual laboratories in school or even at home.

I think they are effective in case the experimental process is very slow and / or complex and not compatible with the teaching time available, the experiments involve risks to the health and physical integrity of learners and/or the learning activities require. Also it includes the practical aspects and provides knowledge to students because sometimes it's not possible to conduct the lab classes inside the labs, so I think in that situation, virtual labs will be good for them.

the virtual laboratory is able to enhance students' problem solving, critical thinking, creativity, conceptual understanding, science process skills, lab skills, motivation, interest, perception, and learning outcomes. Virtual labs help teachers and students save time and effort because they don't need to adhere to certain times to enter the lab, or to move from one place to another.

90%.. I believe they are effective especially when there are no sufficient resources to do the experiments in actual labs, and when the experiment is difficult to implement. However sometimes it's more effective for memory's sake to manipulate tools and perform the experiment manually.

It enhances the student perception of learning the concept by using digital simulations at his own pace. It may increase his patience and satisfy his imagination though this method. In this way, student can play the virtual lab over again if some doubt arises.

On the other hand, two teachers stated they do not see virtual laboratories effective, and on some occasion, it all depends on the school and teachers to make it effective or not.

The third question targeted the difficulties of using virtual laboratories in science lessons. In this question, teachers showed clear understanding of the difficulties they faced and the possible difficulties they may encounter in the future. Teachers' responses can be categorized into four concerns; the first, shared among most teachers, was the shortage and the limitation of the resources available to teachers. In addition, many of useful resources

are paid and expensive. The second concern was problems related to infrastructure and internet connectivity, which affect the flow and success of the virtual laboratories in the science classes. The third difficulties teachers pinpointed were that students could lose out on the chance for hands-on experience and other valuable information, where they have to use their five senses or to design and build models. Teachers also had concerns about how virtual laboratories can limit students' creativity. The last concern teachers expressed was on how they can include all students, and if they would be able to include and provide the necessary support to SEN students.

Below are some of the teachers' responses.

Most sites are paid and schools usually do not provide financial support; also monitoring students is more difficult than usual labs.

Some students need full assistance especially SEN. They must do the virtual lab with someone beside them to explain and cater their questions.

I think one of the difficulties is the disadvantage that students cannot able to experience the building and setting up the structure of the model for example. I think doing it manually or hands-on can develop creativity, mechanical and analytical skills.

The difficulties are the disadvantages of using the virtual lab in such a way that the students will not experience the experimental error (tool and human), the qualitative observations such as touching the hot and smelling the fruity scent and the excitement it gives such as mild explosion and changes in colours.

The final question teachers were asked to answer was "How to improve virtual laboratories practices in science lessons?"

In this question, teachers expressed what exactly is needed to improve virtual laboratories practices in science lessons. There was more variation in teachers' response to this question. However, the most common answer was related to having sufficient resources and proper training. In fact, teachers stressed the need for a continuous training program to equip the teachers with the required skills to conduct successful virtual laboratories, engaging the students and achieving the desirable learning objectives.

Teachers also suggested increasing the number and the frequency of science virtual laboratories in high school science lessons.

Furthermore, to improve the virtual laboratories in high school science lessons, teachers believed it was essential to eliminate all issues related to IT and connectivity. Students need to have their devices that can support the virtual lab, the internet connectivity, and the sufficient resources.

Teachers also proposed changing the lesson design in a way that actively engaged students and met their needs.

Finally, teachers suggested opening the window for designing and creating their own virtual laboratories, with the collaboration with IT department in their schools.

1. Ensure all students have their devices 2. Virtual labs contents should be differentiated during programming to meet the needs of all categories of students. 3. Constant training for teachers on how to use virtual lab.

By expanding the library of experiments and by giving each student the enough time to go through the experiment. And why not engage students in developing new virtual experiments in collaboration with the IT department at school. Thank you

By training teachers regularly and provide them with different sites to have diversity.

Encourage the school to buy platform that support virtual labs.

Schools should provide strong Internet and allowed devices

CHAPTER 5: Discussion, Conclusion, Recommendations and Implication, and Limitations

Living in a technological era makes it mandatory to integrate technology with science, preparing students for their future careers and professional life. Technology aims to facilitate life, saving resources and creating an environment more conducive to efficiency and innovation.

Such characteristics can be seen as advantages when using virtual laboratories in high school science lessons.

This chapter presents the discussion of the findings, conclusion, recommendations, and, finally the implications and limitations of the study.

5.1 Discussion

The aim of the study was to investigate high school science teachers' perceptions and practices of science virtual laboratories, using mixed approach methodology and instruments, which are effective in measuring skills (Lai & Viering 2012). The discussion will be based on answering the four proposed questions. The discussion will be divided into two main sections, which will discuss both quantitative and qualitative data resulting from teachers' questionnaire and interviews. The first section will discuss the answer for the first question integrated with demographic information and discussion; the second section will answer the second and third questions about teachers' perceptions and practices. This section includes the demographic information and has been divided into sub-sections for full understanding of the findings.

Questions

- 1.What are the aspects of high school science virtual laboratories in the UAE-Ajman?
- 2.What are the perceptions of high school science teachers regarding virtual laboratories in the UAE-Ajman?

3.What are the virtual laboratory practices of high school teachers in the UAE-Ajman?

4. What demographic differences do high school science teachers have regarding their perception of virtual laboratories in the UAE-Ajman?

5.1.1 Discussion of Research Question 1

Aspects of high school science virtual laboratories in Ajman schools

“Curricula are required in order to help the learning process to be carried out in a planned, programmed and productive manner” (Zorluoğlu, Bağrıyanık & Şahintürk 2019). Teachers answered questions in matter of virtual laboratories curriculum. “In science curricula, it is aimed to educate individuals who research, question, make effective decisions, solve problems, are active in collaborative processes and able to communicate effectively” (Zorluoğlu, Bağrıyanık & Şahintürk 2019). Teachers showed positive attitude and practices; the vast majority of them indicated that a science curriculum that includes virtual laboratories helps students to learn. These curricula also improved their knowledge in their own content area. Finding this information easy to use, this led them to feel confident with curriculum integrated with virtual laboratories and supporting the virtual mode during curriculum design. On the other hand, teachers pointed out that these virtual laboratories are part of their lesson planning and instructions.

“Teachers’ lack of knowledge and confidence prevents students from learning” (Firat 2020). The fact that many teachers lacked necessary skills affected negatively the online and digital learning integration in digital learning methods. Also some teachers show resistance to learn and develop to use them effectively (CIPD 2021). According to Kim, First & Kim (2021), COVID-19 forced non-negotiable educational paradigm shift, making technology and its applications undoubtedly an integral part of new learning methods, and teachers must adapt and adopt. In fact, teachers in the current study did not show the same level of confidence and support when it comes to the amount of information included in the curriculum design. In addition, teachers underscored their need for training on how to design these curricula and implement them, especially that a modern curriculum should include several factors such as learning outcomes, technological resources (Yapıcıoğlu

2016), content and assessment to enable students' full engagement in complex science events. The second point teachers highlighted is the time needed to prepare lesson with virtual laboratories even though teachers believe they have their own their work load.

Demographics :Overall, both male and female teachers had the same responses, male teachers showed more understanding of the information contained in the designed curriculum, while female teachers believed they received more training and monitoring on science virtual laboratories. Teachers who are teaching different subjects physics, chemistry and biology were on the same page of most of the questions, with teachers who are teaching chemistry showing a higher mean in their responses in comparison to physics and biology teachers.

The final variable was teachers' academic qualifications; that data analysed based on teachers qualifications showed that all teachers have bachelor degree and above, with teachers with a master degree exhibiting high overall mean in response to the total questions.

5.1.2 Discussion for Research Question 2 and Question 3

Teachers' perceptions and practices of high school teachers in UAE-Ajman

Teachers' practices and perception

This part of the discussion will shed the light on the outcomes of data focusing on teachers' practices and perceptions, embedded with demographic information in relation to the answered questions, and how this demographic information could affect or change some aspects.

Teachers were asked if they are confident with their daily lesson planning that incorporate virtual laboratories in high school science lessons; if through conducting virtual laboratories lesson, they can mentor their students and manage the to obtain the desired learning outcomes; and how they found the effectiveness of virtual laboratories mode of teaching. These were crucial to determine if the teachers noticed the advantages of digital science education, especially in aspects of saving time, students' safety, and parents' involvement (Sarioğlu et al., 2020).

The data was analysed and found the overall summaries in relation to different variables (Demographic)

Gender. The results did not show a significant difference between male and female responses. As for students, teachers did not identify any difference when it comes to their own students' gender.

Academic qualification. This variable reflected preferences towards teachers with a master's degree; their mean was higher in comparison to other teachers with different qualifications. On the other hand, teachers with a doctorate degree were less optimistic, and their mean was the lowest in comparison.

Teaching experience. The data studied was based on five different experience categories; each five years of experience were considered one batch. The results were in favour of teachers with more than 20 years of experience. This is could be due to their long experience in managing, mentoring and achieving the learning objectives. Nevertheless, teachers with more than 20 years of experience implies teachers are over then 43 years of age; this is very optimistic, considering how older teachers with more experience are open to new technology and new teaching approaches. In contrast, the results for teachers with less than five years of experience came with the least mean. Again this was unpredictable for a supposedly younger generation in age and experience; their standard deviation was the highest, meaning there were differences among the responses of teachers with less experience.

Science Subject Taught. The means were close in both chemistry and physics, but not the same for biology with a lower mean. The conviction among biology teachers was the need to perform some physical dissections; however, virtual laboratories can help greatly in genetics, microorganisms and organelles.

Teachers were asked to define what virtual laboratories are, and a large majority of them showed they well understood the meaning of virtual laboratories. The results showed some variation in teachers' understanding of virtual laboratories as being exclusively online labs.

Teachers' Perceptions and practices on virtual laboratories effectiveness on students' achievements

Investigating new aspects with regard to teachers' perceptions and practices of virtual laboratories in relation to their own students, the focus here is to check the effect of virtual laboratories on students' achievements, class engagement, improving their learning skills, and whether virtual laboratories have a positive impact on the students learning and attitude during practicing virtual laboratories, teachers pre-COVID 19 pandemic used to invest huge efforts to equip their lessons with online resources to achieve proficiency (Karuppannan & Mohammed 2020). The results will be discussed as overall mean in comparison to different variables.

As discussed above, the gender of teachers or gender of their own students did not affect the results; both males and females agreed that virtual laboratories in science lessons have a positive impact on students' learning. The same was true for teachers' different qualifications; teachers with different qualifications had also the same assumption on the effectiveness of science virtual laboratories on students' achievements, class engagement, and their own science learning in general. This is a very big achievement to the UAE education system, especially while providing equal access to education for both genders, as some studies indicate that gender equality has not been achieved for all students, and that both gender do not necessarily have the same access to science education (Idin & Donmez 2017)

Teachers whose teaching experience was more than 10 years had the same mean of results as overall, while teachers with less than five years showed less conviction in the validity of virtual laboratories as a positive teaching mode for students with tangible results; nevertheless, their mean was in the range of "agree".

The chemistry, biology and physics teachers agreed that virtual laboratories in their teaching subjects have a positive impact on students' learning and achievements, but again biology teachers got the lowest mean in comparison to chemistry and physics teachers.

Finally, participant teachers agreed that virtual laboratories are effective tools (Bicen & Kocakoyun 2018; Nadeem 2020). However, this effectiveness may depend on how

successfully teachers will conduct these virtual laboratories and the quality the virtual laboratories resources schools provide to teachers to perform better virtual laboratories within high school science lessons. In addition, although virtual labs can help in improving students' attainment and enhancing their skills, they cannot replace the traditional laboratories; therefore, teachers encouraged using virtual laboratories side by side with regular labs. They promote virtual laboratories to fill the gaps where regular laboratories fall short. The reasons teachers gave as to why virtual laboratories should not be a full replacement of regular laboratories, included their concern on how inclusive virtual laboratories could be, and if they will be able to serve all students, especially students with special needs. The other concern was that as they are previously planned and designed, virtual laboratories could limit students' creativity and limit the development of some the skills required for the 21st century. (Aaron and Lipton 2018)

Teachers' perceptions and practices on virtual laboratories resources and readiness.

This part of discussion covers the provided resources from schools to support teachers in promoting virtual laboratories in high school science lessons. Teachers are aware on how to succeed in virtual laboratories integrations; they need a robust infrastructure, internet access, or any kind of relevant resources that could be used as virtual laboratories in high school science curriculum and lessons. Finally, they indicate how they are in need for proper training to be able to apply this technological teaching approach.

In this section, teachers' responses were too low in means average in comparison to all previous questions, in fact, with all variables, mostly having a near mean.

Teachers were not happy with the provided resources by their own schools; the infrastructure and internet connectivity seem to be not to the expected level. Meanwhile, it seems high school science students have their own devices or the school provided them with ones, which it is big advantage. Here, schools may need to review their own internet connectivity and capacity to be able to hold their virtual laboratories successfully without any disconnection. In addition, they need to ensure that no instructional time is lost. In fact, one of the biggest advantages of virtual laboratories is to save time, and with such kind of infrastructure that does not seem applicable here.

Teachers find themselves forced freedom to search for free and readily available virtual laboratories resources to use in their own science lessons; this is due to shortage of virtual laboratories and online resources provided by schools. This has led to consume teachers' energy and time to find efficient virtual laboratories and free resources to use in their high school science lessons.

The final highlight in this section is that all the participating teachers agreed that they need to have a proper training program and mentoring on how they can use virtual laboratories. "There is a need for well-organized individual professional development plans that will follow the professional development of teachers and help them to realize their professional development studies consciously" (Duran, Can & Özer 2020) This need and demand seems to be in one package along with the shortage of resources provided by schools. If the schools contract appropriate technological companies, they will provide a training and mentoring program for high school science teachers, especially that digital skills and competences are major factors in the successful use of digital applications in teaching and learning (Koehler, Mishra & Cain 2013). However, as teachers use their own resources, the training and mentoring programs will be very difficult to be successful and cover all the needs of the teachers who are applying a new approach in teaching and learning.

Teachers suggested many things could be done to improve using virtual laboratories in high school science lessons, and these suggestions could be summarized in a few points.

Teachers demanded proper resources from their own schools; "lack of access, resources, and professional development can have grave consequences for students"(Seiki, Domínguez & Asato 2021); they wanted to know how to differentiate lessons with virtual laboratories, as they are concerned about being able to reach all their own students and provide a proper learning experience to everyone. Some students were encouraging to have more integration with ICT lessons and open the door for students' creativity to design their own virtual laboratories, and this could be a massive step if schools could achieve it.

5.2 Conclusion

The current study was conducted to investigate high school science teachers' perceptions and practices of virtual laboratories in American schools in Ajman, UAE.

The study found that science teachers of three schools, which provide a high school program for students, have adequate knowledge of virtual laboratories, and all of them are aware of the advantages and disadvantages, and what could be done to improve using virtual laboratories in high school science lessons. Although the results did not show any major differences within the provided variables, there was a discrepancy in teachers' understanding of the exact definition and characteristics of virtual laboratories. Teachers stated that virtual laboratories are included in high school science curriculum and daily lesson planning. The three schools have internet and allow high school students to bring or have their own devices; this reflects the schools' attempts in developing and adopting technologies in pedagogical approaches.

Furthermore, teachers agreed on the advantages of virtual laboratories in high school science lessons, like saving time, opening a window for expensive or inapplicable experiments in traditional situations, improving the students' skills and also their attainment and achievements. Nevertheless, these advantages are not to limit or reduce traditional laboratories; teachers insist effective virtual laboratories go side by side with conducting traditional laboratories. An area of concern for teachers was how they can change their lessons during a virtual laboratory or losing on some crucial skills students should have.

Unanimously, teachers agreed on what they need to improve their own practices and assure the success of using virtual laboratories in high school science lessons. Even though schools provide internet, the internet in the schools does not support the smooth functioning of virtual laboratories. Students have random and different types of devices, and some of them cannot support playing the virtual laboratories. Therefore, schools are required to provide students with sufficient resources.

Overall, teachers do not receive appropriate training on how to use and conduct virtual laboratories, as these virtual laboratories are different types of platforms and technologies.

5.3 Recommendations

Based on the results of the current study, answering the four research questions, here are few suggestions and recommendations that may provide support for studies related to science pedagogy and technology integration.

First, school leaders and management should focus on the integration of technology in science instructions and include them in school improvement plans.

Next, school leaders and management should allocate sufficient budget to support and provide all the needed resources to assure the success of virtual laboratories' implementation.

The third point highlights the required shift in pedagogical approach; it needs to move from a teacher-centred approach to a student-centred one, especially as science should be learnt through hands-on activities, resulting in enhancing students' engagement and attainment.

In addition, schools should offer science teachers a professional development program in technological pedagogy approach and in virtual laboratories in specific.

Finally, it is strongly recommended to revise the curricula of high school science subjects with regard to technological pedagogy and virtual laboratories.

5.4 Implications

The current study has some implications. First, teachers' perceptions regarding virtual laboratories are developed based on their own experience. Given that their responses are not based on professional training or workshops, the teachers' perceptions and practices may differ although they work at the same curriculum based schools.

Second, teachers are not consistent when it comes to practicing virtual laboratories in science classes, due to poor planning and lack of available resources. It is recommended that teachers to plan effectively for virtual laboratories lessons and to pursue some technological courses to develop their current technological skills and gain access to new pedagogical science/technology trends.

Third, science and technology integration to use virtual laboratories in science lessons provides a huge opportunity to bring the UAE closer to digitalization of education and build students' confidence in learning science and promote 21st century skills.

5.5 Limitations

This research study is limited due to the small number of participating teachers, who represent the whole body of high school science teachers in three American curriculum schools. In addition, the study was conducted over a short period of time. With regard to data collection, it was done online. Teachers had to complete an online survey and answer the interview questions in writing. It would have been more beneficial if the interview questions could have been answered through a one-to-one interview. Such type of interview can open the door for wider conversation, more explanation and provide insight into each teacher's concerns.

The study was limited to only high school science teachers; it would have also been more beneficial to interview the heads of science department to gain some perspective on how the administration views the teachers' contributions in integrating virtual laboratories in high school science lessons.

Further studies are needed in order to follow closely with teachers, analyse the current resources teachers have, and observe virtual laboratory life lessons. In addition, it is important to include students in future studies to investigate their own perceptions and practices of virtual laboratories and checking if virtual laboratories have any positive impact on their own learning.

Future research studies using quasi-experimental design are also recommended to measure the effect of virtual laboratories on students' progress and attainment, by developing and adopting suitable tools.

Further, expanding the geographic scope of the study to include emirates other than Ajman could be useful in generating findings that can be utilized to inspire decision making and issuing guidelines across the UAE.

In conclusion, despite the limitations of the current study, its significance lies in being a stepping-stone to start conversations on the matter at hand and motivate further investigation into the effectiveness and methods of integrating virtual laboratories in science classes as a whole.

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Appendices

Appendix 1



1 April 2022

To Whom It May Concern

This is to certify that Ms. Inaam Abualhaija with Student ID number 20001597 has been a student on the Master of Education programme at The British University in Dubai since September 2019.

Ms. Abualhaija has successfully completed the taught stage of the programme. She is currently working on his research titled “Investigating High School Science Teachers’ Practices and Perceptions of Science Virtual Laboratories in Private Schools in Ajman, UAE”. She is required to gather data through surveys.

Your permission for her to conduct her research in your organisation is hereby requested. Any support provided to her in this regard will be highly appreciated.

This letter is issued at Ms. Abualhaija’s request.

Yours sincerely,



Dr. Amer Alaya
Head of Student Administration
The British University in Dubai



Appendix 2

Part 1: Teachers' Demographic Information

1.Emirate		2.Curricula/Programmes Offered by your School				
3.Nationality		4.Gender	Female		Male	
5. Age						
6.Academic Qualification	Diploma	Bachelor's Degree		Master's Degree		Doctorate
7.Teaching experience	1-5 Years of Experience	6-10 Years of Experience	11-15 Years of Experience	16-20 Years of Experience	More than 20 Years of Experience	
8.Science Subject Taught	Physics		Chemistry		Biology	
9. Your Current Students' Gender	Female			Male		

Part 2: Science Virtual laboratories Curriculum

This part of questionnaire contains elements related to high school science virtual laboratories curriculum in your science classes, kindly circle the choice that matches your practice.

Please answer questions from 1-11

Use the rate scale to answer the questions

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

	Science Virtual laboratories Curriculum	1	2	3	4	5
1.	I include virtual laboratories when planning for lessons and instructions.					
2.	The curriculum integrated with virtual labs has helped building knowledge in my content area.					
3.	The curriculum I teach includes virtual laboratories that designed to reach all students.					
4.	The curriculum contains virtual lab is helping my students learn.					
5.	The information and display of the curriculum is easy to use.					
6.	The curriculum design has all the information you need and are accessible.					
7.	I am confident in teaching curriculum integrated with virtual labs					
8.	I have a system in planning lessons can work for me.					
9.	I have enough time to prepare science lesson including virtual lab					
10.	I receive a training on curriculum planning and mentoring.					
11.	Virtual mode should be considered when designing science curriculum.					

Part 3: Your virtual lab practices in your science classes

This part of questionnaire contains elements related to your practices of virtual laboratories during high school science lessons.

Please answer questions from 1-22.

Use the rate scale to answer the questions

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

	Your virtual lab practices	1	2	3	4	5
1.	Technology has positive impact on students learning.					
2.	It is easy to prepare lesson with virtual laboratories					
3.	Virtual laboratories valuable education tool.					
4.	Science classes with virtual laboratories are enjoyable					
5.	Virtual laboratories increase students achievements					
6.	Virtual laboratories increase students engagement					
7.	I am confident in using virtual laboratories in science classes					
8.	Virtual laboratories safer in compared to traditional laboratories.					

9.	Virtual lab can save more time than traditional lab					
10.	During conducting virtual lab, you are able to mentor students' progress					
11.	Students are more responsible on their learning during virtual laboratories					
12.	Virtual laboratories help in improving students critical and creative thinking skills					
13.	Students have positive attitudes in practicing virtual laboratories in science lessons.					
14.	Using virtual lab in my lesson can help me in achieving my lesson's objectives like if I used traditional lab.					
15.	Virtual laboratories can help in line with traditional laboratories in achieving learning outcomes.					
16.	Virtual laboratories are effective mode of teaching.					
17.	Virtual laboratories affected my role as teacher positively.					
18.	School infrastructure supports the implementation of virtual laboratories.					
19.	Students have their devices (ipads,tablets,laptop,mobile..etc) during science class.					
20.	Type of technological device students have during science classes can affect the efficiency of virtual laboratories.					

21.	My school provides me with efficient virtual laboratories resources.					
22.	I search for free virtual laboratories to use in my science lessons.					
23.	I receive training on virtual laboratories on regular basses.					

Part 4: Science teachers' perceptions of high school science virtual laboratories

Please answer the below 4 questions.

1. What is virtual laboratory?
2. To what extent do you think virtual laboratories are effective in teaching high school science content? explain
3. What are the difficulties of using virtual laboratories in science lessons?
4. How to improve virtual laboratories practices in science lessons?