QATAR UNIVERSITY

COLLEGE OF EDUCATION

PERCEPTIONS OF UNDERGRADUATE STUDENTS, LECTURERS, AND LAB ASSISTANTS TOWARDS THE USE OF ONLINE LABORATORY IN SCIENCE EDUCATION DURING COVID-19 PANDEMIC

BY

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ABSTRACT

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Perceptions of Undergraduate Students, Lecturers, and Lab Assistants towards the Use of Online Laboratory in Science during Covid-19 Pandemic

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The current study investigates the perceptions towards online science laboratory approach in Qatar. It aims to shed the light on the undergraduate students', lecturers' and lab assistants' perceptions towards online science laboratory during COVID-19 pandemic at Qatar University. Quantitative design is used in this study by a questionnaire. The sample of the study is undergraduate students, lecturers, and lab assistants who were enrolled in any science laboratories under the department of chemistry, physics, or biology. The collected data is analyzed using SPSS program, using T-test and one-way ANOVA. The findings of the study indicate that they have positive perception towards online science laboratories and there are no significant differences in their perceptions attributed to role of the participants at Qatar university whether they are students, lecturers or lab assistants and attributed to the nature of the subject whether chemistry, physics, or biology. However, there are significant differences attributed to the gender for male participants in the study. Consequently, in this situation the researcher recommends more technical trainings at Qatar University to help them implementing online laboratories with high efficiency.

Keywords: online science laboratories, COVID-19 pandemic, perceptions, Qatar University.

DEDICATION

I dedicate the success of this journey to my Family who were the source support and encouragement to me

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CHAPTER1: INTRODUCTION

1.1 Background

Science and technology are the effective power for developing countries' economical force and its growth (Said & Friesen, 2013). They are also essential to the industrial and medicinal fields, which are very important to any country. According to the National vision of Qatar 2030, technology, math and science are necessarily needed for being a developed nation and to have the knowledge-based economy. Qatar needs to invest in people, scientific research and in science and technology context (General Secretariat for Development Planning, 2009).

Science and technology are considered the basis of sustainable development in the country (Richer, 2014). Qatar is doing massive investments and numerous initiatives for development (Al-saadi, 2010). For example, investing in sciences like chemistry and biotechnology will lead to high industrial production (Richer, 2014). Technology is also very important, it can introduce new materials, increase the rate of the production, and decrease of the products' costs (Al-saadi, 2010).

Qatar University is one of the active institutions in Qatar that participates in the sustainable initiatives (Mogra & Furlan, 2017). For instance, it hosts a virtual reality system, which is allowed for researchers, instructors and students to use it ("Virtual Reality Lab | Qatar University", 2021). The aim of having this kind of labs in the university is to help students in understanding difficult concepts in different fields like medicine and engineering ("Virtual Reality Lab | Qatar University", 2021). Qatar University seeks to meet the needs of graduates who can compete with the local and international labor market. One of its procedures of doing so, is by having virtual reality labs by offering those students to graduate with high technical skills and have the opportunity to polish those skills through the use of these labs and the job opportunities they desire in the future ("Virtual Reality Lab | Qatar University", 2021).

The educational process in Qatar University was affected, like any educational institution around the world, by COVID-19 pandemic which is the global crisis that shook the entire world. The pandemic resulted in changing the educational system as we know it worldwide by implementing health emergency precautions which transformed the education from face-to-face learning to online and distance learning

(Espino-Díaz, Fernandez-Caminero, Hernandez-Lloret, Gonzalez-Gonzalez & Alvarez-Castillo, 2020). The majority of the students at Qatar University are following the online distance learning from their homes, except for some cases like students of practical laboratories, graduation projects, etc. ("Fall 2020 Instructions - Updates | Qatar University", 2021).

Using online resources teaching was the compulsory alternative way of teaching science theoretically and practically and the transition was not easy. The theoretical portion of science was being taught through videos, but the laboratories' experiments were difficult to conduct from home. Currently, E-learning resources are being used worldwide for teaching the science laboratories in a virtual manner, simulated or video-demonstrated (Ray & Srivastava, 2020).

Perceptions are what drives the educators' decisions of whether to implement a certain approach and how to implement it. There is a direct relationship between teachers' perceptions and the quality of the educational process, which, consequently, will affect the students learning process (Hassanein, 2010; Dagnew & Asrat, 2016). Teachers are the ones who guide the learning process in the classroom, they are responsible for how the learning process is conducted whether they follow an active-learning student-centered procedure, use modern effective methods of teaching and meaningful activities, or implement digital tools to keep up with the new development and the progress of learning strategies. It is supported by research that using E-tools in the education process, influences students' perceptions positively towards science (chemistry, physics, biology, math, etc..) (Gargalakos & Sotiriou, 2020). Hence, it is very important to discover the students' perceptions, as well, because their perception affect their benefit in a positive or negative way (Brockman, Taylor, Segars, Selke & Taylor, 2020).

1.2 Statement of the problem

The world is facing exceptional period during the covid-19 pandemic, which caused a very huge disturbance in the educational systems around the world (United Nations, 2020). These changes forced many of the educational institutions to change all of their activities to online based to keep the virus from spreading through their social network. Science laboratories are where students practice what they learn theoretically, through

conducting practical experiments to observe the changes happening, understand the laws and conclude the facts. However, as a result of this crisis, these changes in the educational system prevented students from having the chance to practice the science themselves in the laboratories and restrict the lecturers and lab assistants' ways of teaching. In this thesis, the researcher explored the perceptions of students, lecturers, and lab assistants towards conducting science labs in an online manner and will discover whether there are statistically significant differences in the perceptions attributed to the gender (Male, Female), role at Qatar University (Students, Lecturer, Lab assistant) and the nature of subject of science laboratories (Chemistry, Physics, Biology).

1.3 Questions of the study

The purpose of this study is to discover the perceptions of undergraduate students, lecturers, and lab assistants towards the use of online laboratory in science during the covid-19 pandemic in Qatar University. The findings, hence, address the following study questions:

1- What are the perceptions of undergraduate students, lecturers, and lab assistants towards the use of online science laboratory during the covid-19 pandemic in Qatar University?

2- Do perceptions of undergraduate students, lecturers, and lab assistants vary by gender, role at Qatar University, and nature of the subject of science laboratory?

1.4 Objectives of the study

This study aims to investigate the perceptions towards the online labs during the covid-19 pandemic during the fall 2020 semester in Qatar University through the following points:

- To explore the perceptions of students who are enrolled in science labs and their lecturers and lab assistants.
- To examine the differences in the perceptions attributed to the gender.
- To examine the differences in the perceptions attributed to the role (student, lecturer, lab assistant).

- To examine the differences in the perceptions attributed to the nature of the subject of the scientific laboratory (chemistry, physics, biology).

1.5 Significance of the study

The theoretical significance of this study refers to the addition of knowledge, while the practical significance indicates the practical benefits of the study to the society. Both are represented as follows, respectively:

This study will cover the gap of exploring perceptions towards online science laboratory, which previous studies lack. Furthermore, unlike previous literature, it will explore whether there is a significant difference in the perceptions of undergraduate students, lecturers, lab assistants, instead of focusing on only one of them.

As for the practical significance, findings of this study will provide many important outcomes especially during the crisis of covid-19 about the degree of acceptance of undergraduate students, lecturers and lab assistants to the new approach of online science laboratories. This will help educators and practitioners in Qatar to make decisions, alleviate teaching difficulties, and enhance distance learning.

1.6 Operational Definitions

Perceptions towards online science laboratories: it is the unique way of how each person sees online science laboratories from their point of view in terms of the 4 domains of the instrument (Perceived Usefulness, Perceived Ease of Use, Attitude toward Use, Behavioral Intention) and it is measured by the mean values of the responses of the participants to the questionnaire items.

Undergraduate students, lecturers, lab assistants: the undergraduate students, lecturers, and lab assistants who were enrolled in any science laboratories under the department of chemistry, physics, and biology regardless of their majors.

Online Laboratory: it is the method of conducting scientific experiments (chemistry, physics, biology) in laboratories through any form of distance learning whether by online streaming, simulation, video-demonstrating, remote labs, or virtual reality.

Covid-19 Pandemic: it is the duration of the academic semester of fall 2020 at Qatar University according to the academic calendar.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter introduces the literature and previous studies around the perceptions towards the online science laboratory approach during COVID-19 pandemic.

2.2 Literature review

2.2.1 Importance of teaching science

Teaching is a process of transferring skills, knowledge and experiences to a student or group of students. It is a complex process that needs an effort from the teacher to create and set all the conditions in the classroom for students to learn such as using the suitable strategies, technologies, activities, and tools for each topic to achieve the lesson goals (Suliman, 2018). For the teaching process to happen in a classroom, it should consist of a teacher, students, and content to be taught, in which the teacher is trying to make difference in the behavior of the students by motivating them to learn (Sequeira, 2012). The traditional way of teaching has changed and was replaced with the modern way, in which the student has a main role in the class and the teacher is just the guide of the process to make sure that they are going in the right direction. For example, nowadays, students have lots of experiences and many questions, and the teacher's role is to provide them with the tools and resources and guide them to find the answers by themselves. This would need double the effort from the teacher to prepare and organize the best learning environment for the students (Suliman, 2018).

Science is one of the main subjects that students learn in their schools around the world due to its importance (Apanasionok, Hastings, Grindle, Watkins & Paris, 2019). It consists of activities to solve issues and problems around us using different technology applications to teach someone how to think and discover something unknown (Si'ayah, Kurniawati, Velasufah & Setiawan, 2019). Learning science helps students improve and develop their skills and discover new knowledge to understand and interpret the environment around them (Si'ayah, et al., 2019; Apanasionok, et al., 2019). It involves the students in the scientific investigations (Safaah, Muslim & Liliawati, 2017) and teaches them many inquiry skills and techniques (Si'ayah, et al., 2019; Apanasionok, et al., 2019) like predictions and observations to answer question

or to solve problem (Apanasionok, et al., 2019). It also exposes them to the trial-and-error experience to develop the students' sense of invention.

Developing countries are depending on science and technology as the force of economics and growth (Said & Friesen, 2013). Sciences inquiry skills and the technical skills are needed in many sectors in the country. As a result, methods of teaching science in the governmental schools in Qatar is a very crucial topic that concerns many educators due to its effect on students' interest (Said, 2011). According to the Ministry of Development Planning and Statistics, there is few numbers of students engaging in the science and technology disciplines ("education in Qatar statistical profile 2016", 2017). Moreover, statistical reports indicate the students' low achievement in science according to their results in TIMSS (Trends in International Mathematics and Science Study) and PISA (Programme for International Student Assessment) international exams which focus on science skills (Said, 2011; Areepattamannil, 2012; Hejaze, 2018). Consequently, Ministry of Education and Higher education (2020) is studying the process of teaching science in schools which consists of the activities, tools and curriculum to achieve Qatar national vision 2030 (General Secretariat for Development Planning, 2009).

2.2.2 Importance of science laboratories

One of the most important methods for students to learn about phenomenon is doing lab experiments which enhance their learning process (Liu, Valdiviezo-Díaz, Riofrio, Sun & Barba, 2015). Science professors, in fact, consider laboratories as one of the most effective method to prove laws and involve students in lab experiences which consequently can improve their extrapolation and deduction skills and competencies (Hernández-de-Menéndez, Vallejo Guevara & Morales-Menendez, 2019). Students can learn meaningfully when associating lab activities with the science curricula (Faour & Ayoubi, 2018). Moreover, engaging students in practical lab research improves their skills in problem-solving, communication and technology. These essential skills are needed to help them face challenges in their future careers (Qiang et al., 2020; Hernández-de-Menéndez, Vallejo Guevara & Morales-Menendez, 2019).

Lab activities are very effective in helping students gain practical skills by doing experiments to understand the content deeply (Aljuhani, Sonbul, Althabiti & Meccawy,

2018) and gives the students the chance to interact with various problems using science-processing skills. Those skills will polish students to perform scientific activities needed for scientific discoveries to gain new knowledge (Abungu, Okere & Wachanga, 2014). All in all, much research confirmed that laboratories play an essential role in teaching science (Wang, et al., 2014; Wei et al., 2019).

2.2.3 Effect of COVID-19 pandemic on the Education system

The crisis of COVID-19 pandemic has affected people around the world in all sectors (Babinčáková & Bernard, 2020). The transition in the learning process was considered a huge challenge for all educators (Daniel, 2020). Many educational institutions have closed to avoid face-to-face classes due to the spread of the virus, while many governments around the world launched initiatives to carry on the learning process using distance learning (Ali, 2020). There were many disagreements on the content addressed to students, the way of presenting it, teachers' and students' workload and the learning environment itself (Zhang, Wang, Yang, & Wang, 2020). However, governments have solved the issue of face-to-face instruction by requiring the educational institutions to move to the online platforms and virtual learning systems (Daniel, 2020).

The rapid shift of the education systems due to the pandemic has changed everything including the way of teaching sciences. Even the most well-planned syllabus was not efficient enough during such times (Baker & Cavinato, 2020). It forced science teachers in schools to integrate technology and switch to virtual learning environments through many electronic platforms like Microsoft Teams and PhET Interactive Simulations in a very short time (Al Darayseh, 2020). Moreover, most of the degrees at universities have transformed to distance learning as well.

However, this transition was difficult in majors requiring laboratory coursework (Qiang, Guillen, Chen & Ye, 2020). For example, chemistry undergraduate students and related science majors were negatively affected due to this crisis and learning switch that slowdown their work (Qiang et al., 2020; Hernández-de-Menéndez, Vallejo Guevara & Morales-Menendez, 2019).

2.2.4 Online science laboratory approach

Online laboratories are the alternative way for teaching the practical science through distance learning during the period of COVID-19 pandemic. It could substitute

the science physical laboratories in cases of conducting hazardous experiments or in case of lack of tools due to the expensive materials or having non-practical models/systems (Bonde et al., 2014; Sypsas & Kalles, 2018). It also can be a safe alternative solution for students and instructors during the pandemic of COVID-19 to do experiments from home as a simulation, virtual or live streaming using collaborative tools (Ray & Srivastava, 2020). According to Sypsas & Kalles, (2018) research shows that utilizing of laboratory simulation has positively affected the outcomes of the students and their motivation. In fact, using it as supportive educational tool showed higher achievement than students using traditional laboratories (Sypsas & Kalles, 2018).

Online laboratory can be the alternative way to avoid the challenges of Hands-on laboratories in most of the educational institutions. In hands-on laboratories, some devices and equipment are very sensitive and need to be handled professionally (Albaltan, 2011; Taha, 2016). Therefore, the lack of training workshops for teachers and students on how to conduct practical experiments properly made the learning process harder; and some laboratory equipment were damaged due to the misusing of tools (Albaltan, 2011; Taha, 2016). In addition to that, conducting some hazardous experiments requires high level of training for learners to take safety precautions, it also need very well-observing instructors while conducting practical experiments (Alkendy, 2007). Moreover, hands-on science laboratories in schools or universities needs periodic maintenance which, if it was lacking, can affect the sensitivity of the devices (Taha, 2016) that will affect the experiments' results negatively.

There are several forms of online laboratories used in teaching sciences presented as pictures, videos, text, or interactive components (Zupanc, Lehotzky & Tripp, 2021). Practical experiments can be introduced as a form of simple simulation, written instructions provided with illustrative pictures, recorded videos, virtual laboratories, remote laboratories, live interactive demonstrations, and live demonstrations of experiments with data logging systems (Babinčáková & Bernard, 2020).

Every form of online laboratories is different from each other. Simulation is about practical applications that allow students to do online experiments and discover theoretical concepts, knowledge, and principles through changing parameters in a

simulated environment (Cherner, Cima, Barone, Dyke & Lotring, 2019). Remote laboratories are the laboratories which use physical equipment for the experiments and doing exploration and investigation but at a distance (Gargalakos & Sotiriou, 2020). Virtual laboratories are the laboratories which use virtual equipment for the experiments and doing exploration and investigation using a virtual software (Gargalakos & Sotiriou, 2020).

2.2.5 Advantages and challenges of online science laboratories

The approach of online science laboratories has many advantages for students and instructors, which benefit the learning process in general. It provides flexibility in terms of place and time of having the practical activities or conducting the experiments (Darrah, Humbert, Finstein, Simon & Hopkins, 2014; Ling, Lee & Tho, 2017; Lynch & Ghergulescu, 2017; Youssef, 2019) and it saves money which is needed for experiment tools, chemicals and devices (Darrah, et al., 2014; Brockman et al., 2020). Moreover, the duration of doing the experiments itself could be shorter than it takes in the physical laboratories (Aşıksoy & Islek, 2017; Brockman et al., 2020). It also ensures a safe learning environment for students, lecturers and lab assistants while handling hazardous chemicals or working with sensitive instruments or even with sharp equipment (Aşıksoy & Islek, 2017; Ling, Lee & Tho, 2017; Youssef, 2019).

Although there are many advantages to online science laboratories, there are some challenges facing this approach. It needs a special team to set up the online laboratory environment, and it needs devices with high-level standards and high internet speed (Chahry, 2009; Saleh, 2013; Youssef, 2019). Therefore, it needs a high budget to implement it in the educational institutions (Carnevale, 2003). This is in addition to lack of training introduced to the students and instructors on using the online environments to develop their technical skills (Youssef, 2019). Moreover, sometime the language of the online laboratories is considered a challenge for students and instructors because these labs mainly depend on the English language (Chahry, 2009; Saleh, 2013).

2.2.6 Students' and instructors' perceptions

It is important to examine the perceptions of students to science laboratory learning. Students' perception can positively or negatively affect the benefit of online learning (Brockman et al., 2020). According to Salter & Gardner (2016), students'

perceptions can be improved by using online learning to prepare for other learning activities. However, the demographics of the participants like gender, age, etc... can affect their perceptions towards learning (Brockman et al., 2020).

The perceptions of instructors affect their way of teaching. Hence, science teacher perceptions are the main factor influencing the learning process (Wei & Li, 2017). Therefore, understanding the perspective of educators towards using online learning is very important. Especially since it will explain the obstacles and challenges they are facing to improve the quality of the education process in science education and will, consequently, affect the student's outcomes (Dagnew & Asrat, 2016).

2.3 Theoretical framework

Constructive learning theory has many common principles with the basics of the online science laboratory. The main approach of this theory is based on student-centered learning (Omar, 2014; Vishal & Aarti, 2016). It is based on students gaining and building their own knowledge by themselves, while supported by instructor authentic tasks (Omar, 2014; Vishal & Aarti, 2016).

The use of technology in teaching applies this theory by causing a fundamental transformation in teaching. It aided in shifting the learning model from teacher-centered learning to open and active student-centered learning, by providing an environment rich with different learning resources and knowledge (Al-hafez, 2009). The constructive theory supports the approach that students should gain, receive, and practice knowledge by themselves to improve their productivity, problem solving skills and critical thinking competencies (Asselin & Branch & Oberg, 2003). Online environments allow learners to participate in multiple spatial environments that allow using of multiplicity of senses that deal with the virtual reality, where students can integrate physically and mentally with the experiences provided by virtual reality technology, and during which they feel they are in a virtual world that allows allowing semi-natural interaction with information (Husain, 2013).

There many ways of applying the constructivism learning theory in science online laboratories. Husain (2013) stated that the virtual reality is a powerful tool that achieves constructive learning, as it sees that the educational reality environment is an

environment through which experiences are gained, and through which collaborative learning, group projects, discussions, simulations, and conceptualization can be supported through multiple systems of virtual reality. In addition, using the simulation gives students the chance to discover information by themselves and doing some practical activities that helps them in building their knowledge in an environment which is similar to the real once (Al-Qadry & Al-kharisha & Al-Azamat, 2015). Moreover, according to Al-Qadry et al., (2015) the instructor can develop an online learning environment rich in educational stimuli by conducting experiments in front of the students and help them build their knowledge through hypothetical situations that are similar to the real experiment. The instructor may also use several online tools such as conceptual maps and modeling tools that are in line with the constructivist theory and emphasize the individual understanding of knowledge and allows for appropriate feedback for students.

2.4 Previous studies:

In this section, the researcher is presenting the previous studies related to the topic of the study. They will be organized depending on the progression of time.

The study of Stuckey-Mickell and Stuckey-Danner (2007) discovered that the students' perceptions towards biology virtual labs. Online surveys about biology virtual labs and face-to-face labs were used in this study after taking labs during the course. The sample of the study was 38 students that were involved in introductory biology courses at Midwestern, urban, community college. Results show that the majority of the students find that face-to-face biology labs are more effective, while some of the students find both biology virtual labs and face to face labs are effective.

The study of Hyder, Choi & Schaefer (2010) aimed to discover the perceptions of the students towards remote lab to be integrated with the Engineering course. The researchers used the experimental method with pre- and post-questionnaires to collect data. 14 mechanical engineering undergraduate students participated in this study during the spring semester of 2010. Results indicated that students' perceptions about the impact of remote lab have improved with the post-questionnaire after performing the experiment.

In a study by Flowers (2011) aimed to discover the perceptions of students towards biology virtual labs. The research sample composed of 19 undergraduate students involved during introductory biology course at a university in the southeastern region which covers the basic biological concepts. Quantitative design was used through a survey. The results of the study showed that students prefer virtual biology labs rather than traditional ones. Moreover, it indicates that students in the virtual labs perceived higher learning comparing with traditional labs. The study recommended discovering the impact of implementing virtual labs in science courses.

Crippen, Archambault and Kern (2012) studied experiences of secondary teachers with the online science labs. The study aimed to investigate the perspective of those teachers towards teaching online science labs. The researchers used the quantitative method in this study using questionnaires with the sample of 35 science secondary teachers from 15 different states in the United Kingdom. The results of the study showed lack in the interaction between the teacher and the students, the engagement of the student and nonverbal communication which made it an obstacle. The study recommended more research for using the communication tools in a better way to be algin with the science nature and its activities which gave the students the chance to be engaged in the learning process.

In the study of Al-Thibiti (2016) investigated the influence of using the science virtual labs on the perceptions of secondary teachers in Kingdom of Saudi Arabia. He used the qualitative design using survey consisting of 5 main dimensions. The sample were 105 science secondary teachers working in the academic year 2015-2016 in Qurayat city in Kingdom of Saudi Arabia. The findings of the study show that science teachers' perceptions were high regarding using the virtual lab. In addition to that, the findings showed significant difference in gender for males, and no significant difference in teachers' perceptions due to experience except in the domain of the cons of the virtual reality with (10 and more years of experience) compared to (5 to 10 years of experience). No significate difference in variables of qualification, educational qualification and specialization. He recommended that teachers should be trained through workshops on technics of the science virtual lab.

The study of Aşıksoy and Islek (2017) aimed to discover the effectiveness of the virtual laboratories on the students and their opinions towards it. Experimental

method was used with semi-structured interviews and using pre- and post-physics laboratory attitude scale. The sample consisted of 42 high school students (21 students in the control group and 21 students in the treatment group) who were enrolled in the computer education and educational technologies, 16 students participated in the interviews. The results showed positive opinions towards the physics virtual labs experience.

The study of Lynch and Ghergulescu (2017) aimed to investigate the teachers' perspectives towards the science virtual labs. Survey and interviews were used for collecting data from science teachers. The sample consists of 95 science teachers from 76 different schools. The findings revealed that teachers have positive perspective towards virtual labs.

The study of Ghaith (2017) aimed to discover the science teachers' perceptions towards the science virtual labs. He used perspective scale with 42 preparatory science teachers from 14 different preparatory schools in Saudi Arabia. The results showed that preparatory science teachers have positive perceptions towards the science virtual lab.

The study of Ling Lee & Tho (2017) aimed to discover the opinions of chemistry students, lecturers and lab assistants towards chemistry remote laboratory. They used quantitative and qualitative method using interview and questionnaire. The sample consisted of 81 students, 5 lecturers and 2 lab assistants. The findings showed that positive responses towards the chemistry remote labs from the perspectives of chemistry students, lecturers and lab assistants in University Pendidikan Sultan Idris (UPSI).

The study of Rowe, Koban, Davidoff and Thompson (2017) assist the experience of the students during their online lab course in distance learning program. Quantitative design was utilized in this study using a satisfaction and perception survey distributed to a group of 160 students (90 studying general chemistry course and 70 studying organic chemistry II) studying the lab and course online and 107 students studying chemistry II course and lab by the traditional method. The results showed that respondents of students taught online was the same experience or better than the experience of traditional method.

The study of Youssef (2019) aimed to discover the opinions of the biology teachers and the coordinators towards using the virtual lab and investigate whether there

is significant difference in the 4 variables in the study gender, position, qualifications, and years of experience. The descriptive method was used using a questionnaire of 40 statements. The sample of the study was 298 biology secondary teachers and coordinators in schools in Kuwait. The results show that using virtual lab is very important with relative weight of 92.7%. Moreover, the results show significant difference for the variables of gender, position and years of experience, while there was no significance difference for the qualifications.

The study of Dickson-Karn (2020) studied the feedback of the students on the distance learning in chemical analysis lab during covid-19 pandemic in the course of spring 2020. A survey was used to investigate the opinions and thoughts of the students. The sample of the study is 11 second-year undergraduate students in analytical chemistry course. The results indicated that virtual labs are useful for solving short-answer assignments while face-to-face labs are better for students to write lab reports.

The study of Brockman, Taylor, Segars, Selke, & Taylor, (2020) aimed to examine the perceptions of students towards the microbiology online lab and in-person lab experiences. Experimental method used and data were collected using online questionnaire. The sample consisted of 2 groups: 164 undergraduate medical first year used the online microbiology lab and 83 undergraduate medical second year used in-person microbiology labs. The results revealed that students support the online labs but most of the students support blend of the two labs (online and in-person labs).

2.4.1 This study in relation to the context of the previous studies

This study agreed with the previous studies in the aim of the study and investigating the perceptions towards the online labs. It also agreed with (Stuckey-Mickell & Stuckey-Danner, 2007; Flowers, 2011; Crippen, Archambault and Kern, 2012; Al-Thibiti, Malkawi & Jawarneh, 2016; Lynch & Ghergulescu, 2017; Ghaith, 2017; Ling, Lee & Tho, 2017; Youssef, 2019) in using the descriptive method, while (Aşıksoy & Islek, 2017; Rowe et al, 2017; Dickson-Karn, 2020; Brockman, 2020) used the Experimental method.

Moreover, it agrees with (Stuckey-Mickell & Stuckey-Danner, 2007; Hyder, Choi & Schaefer, 2010; Flowers, 2011; Crippen, Archambault and Kern, 2012; Al-

Thibiti, Malkawi & Jawarneh, 2016; Rowe et al, 2017; Youssef, 2019; Dickson-Karn, 2020; Brockman, 2020) in using questionnaires in collecting data, while (Lynch & Ghergulescu, 2017; Ling, Lee & Tho, 2017) used the survey and interviews. In addition (Aşıksoy & Islek, 2017; Ghaith, 2017) used scales for attitudes and perspectives.

It also agrees with the study of (Ling, Lee & Tho, 2017) in the sample of the study students. lecturers and lab assistants but they studied them on the chemistry department, this study was different in studying all three science departments (chemistry, physics, biology) in the university. While (Stuckey-Mickell & Stuckey-Danner, 2007; Hyder, Choi & Schaefer, 2010; Flowers, 2011; Rowe et al, 2017; Dickson-Karn, 2020) in having college students as their sample. While the study of (Aşıksoy & Islek, 2017) having school students as their sample (Crippen, Archambault and Kern, 2012; Al-Thibiti, 2016; Lynch & Ghergulescu, 2017; Ghaith, 2017; Youssef, 2019) on schoolteachers.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction

This chapter introduces the study's design, population, sample, instrument for collecting data, and procedures that are used to answer the questions of the study, to explore the perceptions of undergraduate students, lecturers, and lab assistants towards the science online laboratories (Chemistry, Physics, Biology) in Qatar University.

3.2 Population

This study focused on three different populations at Qatar University as shown below in table (1). The first population is undergraduate students who enrolled in any science laboratory courses in the department of chemistry, physics, or biology, regardless of their majors, in the semester of fall 2020. They counted 3039 students, distributed as 1090 chemistry students, 1309 physics students, and 641 biology students according to the official site (My banner) of Qatar University for fall 2020 semester. The second population is the lecturers from the science departments (chemistry, physics and biology) at Qatar University, who were teaching labs in the semester of fall 2020. They counted 49 lecturers: 23 chemistry lecturers, 12 physics lecturers, and 14 biology lecturers according to the official site (My banner) for Fall 2020 semester. The third population is lab assistants from the science departments (chemistry, physics and biology) at Qatar university who were helping with the labs in the semester of Fall 2020; they were 25 lab assistants: 9 chemistry lab assistants, 3 physics lab assistants, and 13 biology lab assistants according to the official site (My banner) for Fall 2020 semester.

The reason behind choosing these three populations is to explore their perceptions towards the online labs, during this exceptional period of COVID-19 pandemic that has transformed most of the teaching and learning activities to be online and distance. Therefore, we can predict their acceptance for the idea of having online labs, which will affect their performance in science (chemistry, physics, biology) in this period at the University.

Table 1 Distribution of the population of the study

No.	Chemistry	Physics	Biology	Total
Students	1090	1,308	641	3039
Lecturers	23	12	14	49
Lab assistants	9	3	13	25
Labs	69	56	59	184

3.3 Sample (participants)

This study focuses on three categories at Qatar University (undergraduate students, lecturers and lab assistants) who were enrolled in science (chemistry, physics and biology) labs in the semester of fall 2020. The convenient sample was used in this study. The researcher sent the online questionnaire for all the population participants and received as many responds as possible.

The participants that responded to the questionnaire were 285 classified into 259 students which means 8.52% of the population, 14 lecturers who represented 28.57% of the population, 12 lab assistants who represented 48% of the population. The sample from both genders was206 females (72.28% of the sample) and 79 males (27.72%), in different science departments: chemistry 107, which represented 37.54% of the sample, physics 58 (representing 20.35% of the sample), and biology 120 (representing 42.11% of the sample) as shown in table (2) below.

Table 2 Classification of the participants and their percentage in the sample

No.	Sample	Population	Percent
Students	259	3039	8.52%
Lecturers	14	49	28.57%
Lab assistants	12	25	48%
Total	285	3113	9.16%

3.4 Study design

The researcher used the Descriptive methodology in this study to investigate the perceptions of university undergraduate students, lecturers, and lab assistants towards science online labs during COVID -19 pandemic at Qatar University. This method is a

type of research that is mainly used to accurately describe an existing phenomenon (Atmowardoyo, 2018) and one of its features is to answer the (what) type of questions (Nassaji, 2015) and collecting data through online questionnaire that needs qualitative analysis (Atmowardoyo, 2018), which makes it suitable to answer the questions of the study.

In this study, the convenient sample was used. Convenience sampling strategy is a non-probability sampling technique in which the participants can be easily reached and accessible to the researcher (Taherdoost, 2016). In this study, the researcher tried to reach all the population by sending them emails through their Qatar university emails. However, not all of them responded as mentioned above.

3.5 Instrument

The researcher designed an online questionnaire to discover the perception of undergraduate students, lecturers and lab assistants towards science online labs referring to the previous studies such as (Abu Shanab & Odeh & Hodrob & Anabtawi, 2012; Diwakar & Achuthan & Nedungadi, & Nair, 2011; Chan & Fok, 2009; Laronde & MacLeod, 2012; Heintz & law & Manoli & Zacharia & Riesen, 2015; Daineko & Dmitriyev & Ipalakova, 2016; Theqa, 2011; Al-hasan & Ahmed, 2015; Ling & Lee & Tho, 2017) and with the help of experts in the curriculum and assessment field. The questionnaire consists of two sections; the first section includes the demographic information addressing the variables of the study (gender, role, subject). The second section constituted 36 items classified into 4 domains (Perceived Usefulness, Perceived Ease of Use, Attitude toward Use, Behavioral Intention) as shown below in table (3), with 5 Likert scale (strongly agree, agree, neutral, disagree, strongly disagree). The questionnaire consists of 24 positive items (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 17, 23, 24, 25, 26, 27, 28, 29, 33, 34, 35, 36) and 15 negative items (11, 12, 13, 14, 15, 16, 18, 19, 20, 21, 22, 30, 31, 32).

Table 3 No. of items in each domain of the questionnaire

No.	Domains	No. of items
1	Perceived Usefulness	16
2	Perceived Ease of Use	7
3	Attitude toward Use	8
4	Behavioral Intention	5
	Total	36

3.6 Validity and reliability of the instrument

3.6.1 Questionnaire validity

The questionnaire was designed referring to the previous studies and reviewed by 12 specialists in the Education field in both educational sciences and physiological sciences from two different Universities (Qatar University and Ain Shams University), as shown in the appendix C, to check the content itself and the clarity of the language. The researcher edited the first draft based on their comments to reach the final draft of the questionnaire as shown in the appendix.

Changes made on each of the questionnaire domains on the first draft.

In the first domain (Perceived Usefulness), the researcher removed item no. 5 and item no. 10 and made some changes and paraphrased items no.7, 14, 15, 16. In the second domain (Perceived Ease of Use), the researcher removed items no. 18, 20, 22 and made some changes and paraphrased items no. 23, 26, 27. In the third domain (Attitude toward Use), the researcher combined some items together since they are related such as combine item no. 28 with item no. 29 and combined item no. 33 with item no. 34. Moreover, the researcher removed item no. 30 and item no. 37 and paraphrased item no. 38. In the fourth domain (Behavioral Intention), the researcher removed item no.39 and paraphrased item no.40 and added 3 more items on this domain.

3.6.2 Questionnaire reliability

For checking the reliability of the questionnaire, the researcher has distributed it to a pilot sample of 40 participants and calculated Cronbach alpha for all domains: (Perceived Usefulness, Perceived Ease of Use, Attitude toward Use, and Behavioral Intention), which were - as shown in table (4) below – (0.924, 0.624, 0.882, 0.668) respectively. and the value of Cronbach alpha was high 0.954. According to Ursachi, Horodnic & Zait (2015) the reliability values of Cronbach alpha from 0.6 to 0.7 is considered acceptable and values of Cronbach alpha from 0.8 and above is very good level of reliability. The table below shows high reliability for the questionnaire. Hence, the instrument can be trusted for the study because it shows high validity and reliability.

Table 4 No. of items and values of Cronbach alpha of each domain

Domain	Number of items	Cronbach alpha
Perceived Usefulness	16	0.924
Perceived Ease of Use	7	0.624
Attitude toward Use	8	0.882
Behavioral Intention	5	0.668
The whole instrument	36	0.954

3.7 Study Procedures

The researcher revised the literature that is related to this study. The researcher designed the instrument as a first draft of the questionnaire with the help of the literature. The validity of the instrument was checked through presenting it to specialists in the Education field. The reliability of the instrument was checked through calculating Cronbach alpha of the responses of the participants in the piloting group. Then the researcher applied to get the QU-IRB ethical approval on the instrument to collect the data of the study. After that the researcher contacted the science (chemistry, physics and biology) departments for distribution of the online questionnaire among undergraduate students, lecturers and lab assistants who were involved in science lab during Fall 2020 semester. Then the researcher collected responses online from the

participants. Then the researcher used SPSS to process the data collected and chose the suitable tests for the data.

3.8 Data Analysis procedures

After collecting online responses from the participants, the data was processed using SPSS, using different tests. Calculate the frequencies, percentages and means for the responses to each item in the four domains for the first question. Using T-test to examine whether there are statistically significant differences attributed to the gender (Male, Female) or not and using ONE WAY ANOVA test to examine whether there are statistically significant differences attributed to the role (Student, Lecturer, Lab assistant) and attributed to the subject (Chemistry, Physics, Biology) for the second question.

CHAPTER 4: DATA ANALYSIS

4.1 Introduction

This chapter represents the results of 285 questionnaire responses. Collected data is analyzed with the suitable test to answer each question of the study. The data analysis is ordered as the study questions as follows:

1- What are the perceptions of undergraduate students, lecturers, and lab assistants towards the use of online science laboratory during covid-19 pandemic in Qatar University?
2- Do perceptions of undergraduate students, lecturers, and lab assistants vary by gender, role at Qatar University and nature of the subject of science laboratory?

4.2 Research question 1. What are the perceptions of undergraduate students, lecturers, and lab assistants towards the use of online science laboratory during covid-19 pandemic in Qatar University?

To answer this question, descriptive statistics is conducted. The means (M) and the standard deviations (SD) of the responses of the participants is calculated to the questionnaire 4 domains (Perceived Usefulness, Perceived Ease of Use, Attitude toward Use, Behavioral Intention). The higher the mean values, the more positive the perceptions were towards the online science laboratories. The mean values are interpreted using the following scale as shown below in table (5).

Table 5 Scale of mean values.

	Range	Scale
1	(1 - 1.79)	Strongly Disagree
2	(1.8 - 2.59)	Disagree
3	(2.6 - 3.39)	Neutral
4	(3.4 - 4.19)	Agree
5	(4.2 - 5)	Strongly Agree

The criteria of determining the scale (level of agreement) with the items and domains by the mean values of each item and each domain. The researcher divided the values to 5 levels depending on the 5-point Likert scale used in the questionnaire (from 1-5). The range calculated (5-1 = 4) and then it is divided on the number of intervals which is 5 to get the length of the interval (4/5 = 0.8). This value is added to the least value in the scale, which is (1), to determine the maximum value of the first interval. The same procedure is done to the rest of the intervals as can be seen in table (5) above. From 1 to 1.79 is considered (Strongly Disagree) and from 1.8 to 2.59 is considered (Disagree) and from 2.6 to 3.39 is considered (Neutral) and from 3.4 to 4.19 is considered (Agree) and from 4.2 to 5 is considered (Strongly Agree). The table is reversed when the items are negative. The scale from 1 to 1.79 is considered (Strongly Agree) and from 1.8 to 2.59 is considered (Agree) and from 2.6 to 3.39 is considered (Neutral) and from 3.4 to 4.19 is considered (Disagree) and from 4.2 to 5 is considered (Strongly Disagree).

4.2.1 The first domain (Perceived Usefulness)

This domain consists of 16 items related to the usefulness of the online science laboratories divided into 10 positive items (1, 2, 3, 4, 5, 6, 7, 8, 9, 10) and 6 negative items (11, 12, 13, 14, 15, 16) arranged in order from the highest to the lowest mean as shown below in table (6). The mean values are high (higher than 3) for all items in this domain. The highest value in this domain was for item no. (15) with values (M = 4.13, SD = 1.118) and the least value was for item no. (8) with values (M = 3.2, SD = 1.366) and the mean value for the whole domain is (M = 3.725, SD = 1.175). According to the scale in table (5) above, 8 items of this domain is Agree which are items (1, 2, 3, 4, 5, 7, 9, 10) and 6 items is Disagree (11, 12, 13, 14, 15, 16) which are the negative items, and 2 items are Neutral (6, 8). Hence, the mean of the whole domain (M = 3.725, SD = 1.175) reflects that in general participants Agree in this domain.

Table 6 The Mean and SD values of the First domain (Perceived Usefulness)

Order	No.	Items	Mean	SD
1	15	Limits the development of manual laboratory work skills (handling laboratory materials, tools, and instruments)	4.13	1.118
2	11	makes students miss the practical experience of the real lab	4.11	1.092
3	2	provides safe environment for experiments	4.05	1.037
4	16	limits the teamwork	3.96	1.227
5	14	limits direct interaction with colleagues	3.92	1.19
6	13	limits direct interaction with the teacher	3.91	1.19
7	4	supports individual learning	3.85	1.116
8	7	helps students in understanding science concepts	3.67	1.153
9	1	provides a good integration of technology	3.66	1.128
10	5	provides immediate feedback for students	3.65	1.164
11	3	helps in modeling abstract concepts	3.6	1.148
12	9	makes data analysis easier	3.59	1.167

Order	No.	Items	Mean	SD
13	12	increases the plagiarism rate in the lab activities	3.58	1.18
14	10	helps students in answering questions that puzzle them	3.43	1.21
15	6	improves students' performance in science	3.29	1.315
16	8	increases students' engagement in the learning process	3.2	1.366
	The mean of the whole domain		3.725	1.175

4.2.2 The second domain (Perceived Ease of Use)

This domain consists of seven items related to the Ease of Use of the online science laboratories divided into two positive items no. (17, 23) and five negative items no. (18, 19, 20, 21, 22) arranged in order from the highest to the lowest mean as shown in table (7) below. The mean values for this domain are high (higher than 3.5). The highest value in this domain was for item no. (17) which is (M = 3.87, SD = 1.029) and the least value was for item no. (23) which is (M = 3.53, SD = 1.093) and the mean of the whole domain is (M = 3.719, SD = 1.08). According to the scale in table (5) above, two items of this domain is Agree which are items no. (17, 23) and five items is Disagree (18, 19, 20, 21, 22) which are the negative items. Hence, the mean value of the whole domain (M = 3.719, SD = 1.08) reflects that in general participants Agree in this domain.

Table 7 The Mean and SD values of the Second domain (Perceived Ease of Use)

Order	No.	Items	Mean	SD
1	17	provides flexibility in choosing the time and place	3.87	1.029
2	18	requires a lot of special technical training	3.87	0.984
3	21	Technical issues present a problem while working in the laboratory	3.77	1.045
4	22	makes the lab work assessment difficult	3.75	1.121
5	20	There is a difficulty in getting measurements accurately	3.64	1.213
6	19	needs specific programs like: (LabXchange – Labster)	3.6	1.075
7	23	makes the preparations needed for the experiment easier	3.53	1.093
The mean of the whole domain			3.719	1.08

4.2.3 Third domain (Attitude toward Use)

This domain consists of eight items related to the Attitude toward Use of the online science laboratories divided into six positive items (24, 25, 26, 27, 28, 29) and two negative items (30, 31) arranged in order from the highest to the lowest mean as shown in table (8) below. The mean values are relatively high (higher than 3). The highest

value in this domain was for item no. (31) which is (M = 3.67, SD = 1.232) and the least value was for item no. (25) which is (M = 3.04, SD = 1.345) and the mean value of the whole domain is (M = 3.264, SD = 1.269). According to the scale in table (5) above, six items of this domain is Neutral which are items no. (24, 25, 26, 27, 28, 29) and two items is Disagree (30, 31) which are the negative items. Hence, the mean value of the whole domain (M = 3.264, SD = 1.269) reflects that in general participants are Neutral in this domain.

Table 8 The Mean and SD values of the Third domain (Attitude toward Use)

Order	No.	Items	Mean	SD
1	31	My role is limited to watching only during the online lab	3.67	1.232
2	30	I feel frustrating during using the online lab	3.42	1.261
3	28	I can work faster on the experiments online	3.33	1.249
4	29	I will use it more frequently when there is access to it	3.24	1.323
5	26	provides an opportunity for creative research work	3.19	1.214
6	24	provides an interactive and motivational environment	3.11	1.221
7	27	increase the students' motivation to learn science	3.11	1.306

Order	No.	Items	Mean	SD
8	25	provides simulation equivalent to the real lab.	3.04	1.345
	The mean of the whole domain		3.264	1.269

4.2.4 Fourth domain (Behavioral Intention)

This domain consists of five items related to the Behavioral Intention to use the online science laboratories divided into four positive items no. (33, 34, 35, 36) and one negative item no. (32) arranged in order from the highest to the lowest mean as shown in table (9) below. The mean values are high (higher than 3). The highest value in this domain was for item no. (34) which is (M = 3.85, SD = 0.938) and the least mean value was for item no. (32) which is (M = 3.32, SD = 1.358) and the mean value of the whole domain is (M = 3.602, SD = 1.177). According to the scale in table (5) above, four items of this domain is Agree which are items no. (33, 34, 35, 36) and one item is Neutral which is item no. (32) which is the negative item. Hence, the mean value of the whole domain (M = 3.602, SD = 1.177) reflects that in general participants Agree in this domain.

Table 9 The Mean and SD values of the Fourth domain (Behavioral Intention)

Order	No.	Items	Mean	SD
1	34	I will suggest improvements to it for the future use	3.85	0.938
2	35	I look forward learn more about it	3.71	1.118

Order	No.	Items	Mean	SD
3	36	I will seek to participate and attend forums and conferences on the use of online laboratories	3.59	1.229
4	33	I prefer to use it in the future simultaneously with the real laboratory	3.54	1.243
5	32	I am not planning to use it in the future	3.32	1.358
The mean of the whole domain			3.602	1.177

4.3 Research question 2. Do perceptions of undergraduate students, lecturers, and lab assistants vary at (α=0.05) by gender, role at Qatar University and nature of the subject of science laboratory?

This research question seeks to find whether there are any statistically significant differences ($P \leq 0.05$) in undergraduate students', lecturers' and lab assistants' perceptions in the 4 domains of the questionnaire (Perceived Usefulness, Perceived Ease of Use, Attitude toward Use, Behavioral Intention) attributed to their gender, role at Qatar University and the nature of the subject of science laboratory. A *t*-test and one-way ANOVA test were used with the four study domains to discover the significant differences between study domains and the demographic variables.

4.3.1 Gender and study domains. To answer the research question regarding the gender, the researcher used *T-test* to check the statistically significant differences ($P \leq 0.05$) in perceptions towards the 4 questionnaire domains (Perceived Usefulness, Perceived Ease of Use, Attitude toward Use, Behavioral Intention) and the gender (Male, Female). The results are as shown in the following table (10):

Table 10 T-test results of the participants' perceptions by gender

Domain	Gender	Mean	Std. Deviation	Std. Error Mean	t	df	Sig. (2-tailed)
Perceived Usefulness	Male	54.6709	14.03724	1.57931	5.363	283	0.000*
	Female	45.9660	11.51939	.80259			
Perceived Ease of Use	Male	17.3671	3.33658	.37539	.886	283	0.376
	Female	16.9029	4.16844	.29043			
Attitude toward Use	Male	27.9367	7.45644	.83892	5.628	283	0.000*
	Female	22.3883	7.44637	.51881			
Behavioral Intention	Male	18.8987	3.79134	.42656	3.937	283	0.000*
	Female	16.7816	4.16324	.29007			

*Significant difference at the level of ($p \leq 0.05$)

As can be shown in table (10) the results of the T-test shows that there are statistically significant differences between participants' perceptions and their gender. The sig. values of all domains show that there are significant differences except in the second domain (Perceived Ease of Use) with the value of 0.376. For the other 3 domains (Perceived Usefulness, Attitude toward Use, Behavioral Intention), we have $P \leq 0.05$ which means there are statistically significant differences in favor to Males; due to the higher mean values of Males to Females as shown above in the table.

4.3.2 The role at Qatar University and study domains. To answer the research question regarding the role of the participants at Qatar University, the researcher used ONE-WAY ANOVA Test to check the statistically significant differences ($P \leq 0.05$) in perceptions of the 4 questionnaire domains (Perceived Usefulness, Perceived Ease of Use, Attitude toward Use, Behavioral Intention) and the role of the participants at Qatar University (student, lecturer, lab assistant). The results as shown below in table (11).

Table 11 One-way ANOVA test results of participants' perceptions by the role at Qatar University.

Domain		Sum of Squares	df	Mean Square	F	Sig.
Perceived Usefulness	Between Groups	460.807	2	230.403		
	Within Groups	46438.267	282	164.675	1.399	0.249
	Total	46899.074	284			
Perceived Ease of Use	Between Groups	25.073	2	12.537		
	Within Groups	4417.643	282	15.665	0.800	0.450
	Total	4442.716	284			
Attitude toward Use	Between Groups	42.509	2	21.254		
	Within Groups	17418.944	282	61.769	0.344	0.709
	Total	17461.453	284			
Behavioral Intention	Between Groups	22.939	2	11.469		
	Within Groups	4907.377	282	17.402	0.659	0.518
	Total	4930.316	284			

*Significant difference at the level of ($p \leq 0.05$)

As can be shown in table (11) the results of the ONE-WAY ANOVA test show that there are No Statistically significant differences ($P \leq 0.05$) in all domains of the questionnaire between participants' perceptions and their role (students, lecturers, lab assistants) at Qatar University.

4.3.3 The nature of science subject laboratory and study domains. To answer the research question regarding the nature of the science subject laboratory, the researcher used ONE-WAY ANOVA Test to check the statistically significant differences ($P \leq 0.05$) in perceptions of the 4 questionnaire domains (Perceived Usefulness, Perceived Ease of Use, Attitude toward Use, Behavioral Intention) and the laboratory subject nature (Chemistry, Physics, Biology). The results as shown in the following table (12):

Table 12 One-way ANOVA test results of participants' perceptions by the science subject

Domain		Sum of Squares	df	Mean Square	F	Sig.
Perceived Usefulness	Between Groups	316.005	2	158.002	.956	.385
	Within Groups	46583.069	282	165.188		
	Total	46899.074	284			
Perceived Ease of Use	Between Groups	30.145	2	15.073	.963	.383
	Within Groups	4412.571	282	15.647		
	Total	4442.716	284			
Attitude toward Use	Between Groups	271.631	2	135.816	2.228	.110
	Within Groups	17189.821	282	60.957		
	Total	17461.453	284			
Behavioral Intention	Between Groups	11.725	2	5.863	.336	.715
	Within Groups	4918.590	282	17.442		
	Total	4930.316	284			

*Significant difference at the level of ($p \leq 0.05$)

As can be seen in table (12) the results of the ONE-WAY ANOVA test show that there is No Statistically significant differences ($P \leq 0.05$) in all domains of the questionnaire between participants' perceptions and nature of the science subject (Chemistry, Physics, Biology) in Qatar University.

CHAPTER 5: DISCUSSION AND CONCLUSION

5.1 Introduction

The aim of this study is to investigate the perceptions of the undergraduate students, Lecturers, and lab assistants towards the online science laboratory during the period of Covid-19. In addition to that, the researcher aims to discover whether there are significant differences attributed to the gender (Male, Female), the role at Qatar university (Student, Lecturer, Lab assistant) and the nature subject of the science lab (Chemistry, Physics, Biology). In this chapter, the results of the study are discussed and interpreted in the same order of the study questions and it is linked to the literature review in the second chapter. Moreover, limitations and recommendations of the study are discussed.

5.2 Research Question 1. What are the perceptions of undergraduate students, lecturers, and lab assistants towards the use of online science laboratory during covid-19 pandemic in Qatar University?

The results revealed that undergraduate students, lecturers, and lab assistants at Qatar University had positive perceptions towards the online science laboratories during the period of Covid-19 Pandemic. Regrading to the domains of perceptions it came in the following order (depending on the mean values): Perceived Usefulness with mean value of 3.725, Perceived Ease of Use with mean value of 3.719, Behavioral Intention with mean value of 3.602, Attitude toward Use with mean value of 3.264, all of them had high mean values, which indicates in general that they have positive perceptions towards the science online laboratories.

These results can be explained considering global trends to transform everything online, including the educational process, using contemporary technology. In light of the rapid knowledge and technical development that we are experiencing today, especially during the period of the COVID-19 pandemic, the distance learning process is required. It is also in line with the modern trends for teaching science subjects in all of their forms and types, which is an integral part of the pedagogy of science education. This explanation is supported by the study of Yousef (2019) that finds a

positive perception from teachers about virtual laboratories. This was due to the investment in technology in education by Ministry of Education.

This finding agreed with the findings of the studies of (Hyder, Choi & Schaefer, 2010; Flowers, 2011; Al-Thibiti, 2016; Aşıksoy & Islek, 2017; Lynch & Ghergulescu, 2017; Ling, Lee & Tho, 2017; Ghaith, 2017; Youssef, 2019) that have positive perceptions towards the online science laboratories. On the other hand, the findings of (Stuckey-Mickell & Stuckey-Danner, 2007; Crippen, Archambault and Kern, 2012) showed that the majority of the participants prefer the face-to-face science laboratories. However, the findings of the study of (Dickson-Karn, 2020) showed that students find that virtual laboratories are better for answering short answer questions, which were given to them as assignments. While the physical laboratories help the students were better in writing lab reports. Moreover, the findings of the study of (Brockman et al., 2020) showed that the students prefer to have both physical and online laboratories together.

The results of each domain are presented as follows:

5.2.1 The first domain: Perceived Usefulness

The findings show that item no. (15) has the highest mean value, that is negative item, which states that: online science laboratory limits the development of manual laboratory work skills (handling laboratory materials, tools, and instruments), and they show disagreement with this item, followed by the item no. (11), that is negative as well, which states that: online science laboratories make students miss the practical experience of the real lab, and they show disagreement to this item too, in the third place is the item no. (2) that is a positive item, which states that: online science laboratories provide safe environment for experiments, and they show agreement to this item. Finally, in the last place is item no. (8), which is a positive item, states that: online science laboratories increase students' engagement in the learning process, and they show a neutral response to this item. Noted that, all the items in the domain have high mean values.

The previous results may be attributed to the participants' attention to the importance of the applied side of science education, which is represented in laboratory

experiments and the importance of using online laboratories during the distance learning educational process which imposed by the situation of the Covid-19 pandemic that affected the world. The reason why statement no. (15), (12) and (2) have the highest mean is that participants might see that the online science laboratories give them the same experience of the face-to-face science laboratories in a safe way of doing experiments and dealing with different chemicals and instruments. However, the reason behind why statement no. (8) has the lowest mean in this domain because the participants may still did not get used to it in a professional way, which affect their engagement in the online science laboratories learning environment.

The findings agree with the study of (Lynch & Ghergulescu, 2017; Ling, Lee & Tho, 2017; Youssef, 2019) which finds that online science laboratories in general, are safe practical environment for students regarding the use of dangerous chemicals or using of sharp equipments.

5.2.2 The second domain: Perceived Ease of Use

The findings show that item no. (17, 18) have the same highest mean, item no. (17) is positive item which states that: online science laboratory provides flexibility in choosing the time and place, and they show agreement with this item, and item no. (18) that is negative which states that: online science laboratories requires a lot of special technical training, and they show disagreement to this item, followed by the item no. (21) that is negative item which states that: Technical issues present a problem while working in the laboratory, and they show disagreement to this item. However, in the last place is item no. (23) which is positive item states that: online science laboratories make the preparations needed for the experiment easier, and they show agreement to that. Noted that, all the items in the domain have high mean values.

This may be attributed to the participants' opinion that online science laboratories are easy and flexible to use it. The reason behind having items no. (17, 18) the highest mean values in this domain might be because these online environments let the students be free in choosing the suitable place and time for having the laboratories which is suitable to their schedules. Moreover, they considerate easy enough to use it and does not require many special trainings technical training which might be because

university students and staff are professional enough to deal with the online science laboratories. In addition to item no. (21) show that Qatar university students and the staff do not consider the technical issues be as big issue while working because they can deal with it and solve it easily which support items no. (17, 18) that they are professional enough to work with this online environment. However, the reason behind why statement no. (23) has the lowest mean in this domain is because the preparation of the online science laboratories is easier, but it still need well preparation whether from the students or from the lecturers and lab assistants.

This finding contradicts with the findings of (Crippen, Archambault and Kern, 2012) that concluded that the preparation of science educators which could be qualified to work and teach in an online laboratory environment is considered a challenge. The researcher attributes that contradict because findings of this study considered to be old comparing to the finding of this study. However, it agrees with the study of (Dickson-Karn, 2020) which concluded that science educators are able to use a mix of synchronous and asynchronous ways of distance learning for online science laboratories which affect the students positively.

5.2.3 The third domain: Attitude toward Use

The findings show that item no. (31) has the highest mean, that is negative item which states that: My role is limited to watching only during the online science laboratory, and they show disagreement with this item, followed by the item no. (30) that is negative as well which states that: I feel frustrating during using the online science laboratory, and they show disagreement to this item too, in the third place is the item no. (28) that is positive item, which states that: I can work faster on the experiments online, and they show agreement to this item. However, in the last place is item no. (25) which is positive item states that: provides simulation equivalent to the real lab, and they show neutral to that. Noted that, all the items in the domain have high mean values.

The researcher may attribute this to the feeling the importance of the participants of their role in the online science laboratories and their ability to work faster online which can give them the opportunity to learn more in a less time. However, they

might be not sure that online science laboratories can be the same experience of the physical real science laboratories.

This study agrees with the study of (Aşıksoy & Islek, 2017) which finds that virtual science laboratory affected the student attitudes towards the physics labs positively. Moreover, it agrees with the findings of the study of Yousef (2019) that concluded that virtual laboratories provide the time needed for conducting the experiments and gives chance for students to repeat it more than one time. Thus, the instructor can follow the improvement of the student performance which can help the instructor to take into account the individual differences between students.

5.2.4 The fourth domain: Behavioral Intention

The findings show that item no. (34) has the highest mean, that is positive item which states that: I will suggest improvements to it for the future use, and they show highly agreement with this item, followed by the item no. (35) that is positive as well which states that: I look forward learn more about it, and they show highly agreement to this item too, in the third place is the item no. (36) that is positive item which states that: I will seek to participate and attend forums and conferences on the use of online laboratories. However, in the last place is item no. (32) which is negative item states that: I am not planning to use it in the future, and they show neutral to that. Noted that, all the items in the domain have high mean values.

The researcher may attribute this to the participants' interest in improving the online science laboratories because of the benefit they see in it, that will affect them later in the future, and they are eager to know more about it through attending forums and conferences to know the last updates in this field.

This finding agrees with the study of (Flowers, 2011) which concluded that many of the science educators are working on creating well online laboratories environment and a lot of research will be working on perceptions of students towards the virtual science laboratories.

5.3 Research Question 2. Do perceptions of undergraduate students, lecturers, and lab assistants vary by gender, role at Qatar University and nature of the subject of science laboratory?

5.3.1 The Gender (Male, Female). The results related to this variable showed that there are significant differences in the perceptions attributed to the gender in 3 of the domains (Perceived Usefulness, Attitude toward Use, Behavioral Intention) for males. However, there are no significant differences in the perceptions between males and females in the second domain which is: Perceived Ease of Use.

The researcher attributes this to the awareness of the usefulness of online science laboratories for males more than females. This might be because most male participants at Qatar university consider that online science laboratories increase students' engagement in the learning process in many ways like modeling the abstract concepts and providing immediate feedbacks which increase the students' motivation to learn science and let them prefer to use it in the future simultaneously with the real laboratory, as shown from their responses. However, both males and females find it easy to use online laboratories to conduct online experiments. The finding of this study differs with the findings of the studies of (Al-Thibiti, 2016; Youssef, 2019) that shows that there are significant differences between genders for females, which can be due to implementing the studies in different countries, creating different circumstances for the participants.

5.3.2 The role (Student, Lecturer, Lab assistant) at Qatar University. The results related to this variable showed that there are no significant differences in the perceptions attributed to the role of the participants (Student, Lecturer, Lab assistant) at Qatar University.

The researcher attributes this finding to the agreement of the viewpoint of students, lecturers and lab assistants at Qatar University towards using online laboratories in terms of the 4 domains of the questionnaire (Perceived Usefulness, Perceived Ease of Use, Attitude toward Use, Behavioral Intention). This finding agrees with the study of (Ling, Lee & Tho, 2017) that concluded that students, lecturers and

lab assistants are having positive perceptions towards remote chemistry laboratories at Pendidikan Sultan Idris University.

5.3.3 Science subject nature (Chemistry, Physics, Biology). The results related to this variable showed that there are no significant differences in the perceptions attributed to the different science subjects' nature whether it was Chemistry, Physics, or Biology.

The researcher attributes this to the integration between all the science subjects (Tambaya, Sabitu & Matazu, 2016) and the findings of this study agrees with the study of (Machira, 2017) which finds that there are no significant differences between students attributed to the nature of the science subject (chemistry, physics and biology) and concluded that students have the same perceptions towards science subjects in general. That indicates how close the science subjects are from each other, which lead to no major differences between them in terms of the perceptions.

5.4 Conclusion

This study investigated the undergraduate students, lecturers, and lab assistants' perceptions towards the online science laboratories at Qatar University during covid-19 pandemic. Online questionnaire was used to collect data. The findings of the study revealed that there are positive perceptions in general towards online science laboratories and there are no significant differences in the perceptions attributed to the role of the participants at Qatar university whether they are students, lecturers or lab assistants and there are no significant differences attributed to the nature of the science subject whether it was chemistry, physics, or biology. However, there are significant differences attributed to the gender for male participants in the study in 3 domains (Perceived Usefulness, Attitude toward Use, Behavioral Intention) while, there are no significant differences in the perceptions between males and females in the second domain which is: Perceived Ease of Use.

These results will benefit Qatar University in particular and science educators around the world in general, as it provides them with useful information about

perceptions of students, lecturers and lab assistants at Qatar university towards the online science laboratories. Moreover, it will offer many new research opportunities on online laboratories. In addition to that, it may create innovative methods to implement these science online laboratories in better ways which will be useful for students' learning process as it will allow them to have access to several modifications on the experiments' parameters. It will also be easier for instructors and lab assistants to use as there will be no prior preparations of lab materials and chemicals for lab experiments. It will also allow them to observe and monitor their students while conducting lab experiments.

5.5 Limitations and future perspectives

This study conducted only quantitative approach by using only questionnaire in collecting data on the perceptions of the participants at Qatar University. Further research can use qualitative approach in collecting data through organizing interviews and focus groups to gather more details from the participants about their perceptions towards the science online laboratories. Moreover, other researchers can use observations to discover how the participants' perceptions are affecting their attitude towards the use of the online science laboratories. Furthermore, this study focuses on the perceptions in higher education towards online science laboratories, hence, further research can focus on the perceptions of participants in schools.

5.6 Recommendations

The results of this study show that the undergraduate students, lecturers, and lab assistants have positive perceptions towards the science online laboratories. The researcher might attribute this result to the high quality workshops and lectures that Qatar university provide so the researcher recommends that the university could continue providing technical trainings for all the 3 categories (students, lecturers, and lab assistants) so they can have the highest benefit of this technology using the online learning systems and platforms. It might also provide simulations that are equivalent to the real lab to increase the students' engagement in the learning process. Moreover, the results of the study also show that there are significant differences in the perceptions

attributed to the gender in 3 of the domains (Perceived Usefulness, Attitude toward Use, Behavioral Intention) for males, so the researcher recommends increases in the awareness of females in these three domains through forums and conferences. In addition to that, Qatar University can permanently accredit the online science laboratories approach for students who prefer distance learning, which will allow many international students to study at Qatar University regardless of their place of residence.

REFERENCES

Abu Shanab, S., Odeh, S., Hodrob, R., & Anabtawi, M. (2012). Augmented Reality Internet Labs Versus Hands-On and Virtual Labs: A Comparative Study. *In 2012 International Conference on Interactive Mobile and Computer Aided Learning (IMCL)* (pp. 17-21). Amman; IEEE Xplore.

Abungu, H., Okere, M., & Wachanga, S. (2014). The Effect of Science Process Skills Teaching Approach on Secondary School Students' Achievement in Chemistry in Nyando District, Kenya. *Journal of Educational and Social Research, 4*(6), 359-372. doi: 10.5901/jesr.2014.v4n6p359

Al Darayseh, A. (2020). The Impact of COVID-19 Pandemic on Modes of Teaching Science in UAE Schools. *Journal of Education and Practice, 11*(20), 110-115. doi: 10.7176/jep/11-20-13

Albaltan, I. (2011). *The use of virtual laboratories in science education at the secondary level in the Kingdom of Saudi Arabia: reality and means of development*. (Unpublished PhD thesis). Umm Al-Qura University, Saudi Arabia

Alhafez, M. (2009). The role of chemistry teachers in facing e-learning Academic accreditation to ensure the quality of qualitative shifts from the traditional teaching method to E-teaching. *College of Basic Education Researches Journal, 8*(3), 51. Retrieved from https://scholar.najah.edu/sites/default/files/Yasmeen%20Sodqi%20Omar%20Dar%20Ibrahim_0.pdf

Al-hasan, A., & Ahmed, H. (2015). The reality of using scientific laboratory technology in teaching chemistry at the Sudanese secondary level (Bahri locality. *Journal of Social Studies and Researches, 10,* 7-24

Ali, W. (2020). Online and Remote Learning in Higher Education Institutes: A Necessity in light of COVID-19 Pandemic. *Higher Education Studies, 10*(3), 16-25. doi: 10.5539/hes.v10n3p16

Aljuhani, K., Sonbul, M., Althabiti, M., & Meccawy, M. (2018). Creating a Virtual Science Lab (VSL): the adoption of virtual labs in Saudi schools. *Smart Learning Environments, 5*(16), 1-13. doi: 10.1186/s40561-018-0067-9

Alkendy, A. (2007). *The effect of a training bag on methods of evaluating laboratory work on science teachers' understanding of these methods and their perceptions towards them*. (Unpublished master's thesis). Sultan Qaboos University, Oman.

Al-Qadry & Al-kharisha & Al-Azamat, O. (2015). The preferred constructive online learning environments for students of science faculties at the university and their relationship to their gender in Jordan. *Dirasat international research journal, 42*(1), 31-46. doi: 10.12816/0017335

Al-saadi, R. (2010). *Effectiveness of Technology Transfer in the Search for Sustainable Development: The Case of Qatar* (PhD DISSERTATION). CRANFIELD UNIVERSITY.

Al-Thibiti, A. (2016). *Secondary science teachers ’perceptions of the effectiveness of employing the virtual laboratory in science teaching in Qurayyat*

Governorate. (Unpublished master's thesis), Yarmouk University, Irbid, Jordan. Retrieved from: http://search.mandumah.com/Record/782684

Apanasionok, M., Hastings, R., Grindle, C., Watkins, R., & Paris, A. (2019). Teaching science skills and knowledge to students with developmental disabilities: A systematic review. *Journal of Research in Science Teaching, 56*(7), 847-880. doi: 10.1002/tea.21531

Areepattamannil, S. (2012). Effects of Inquiry-Based Science Instruction on Science Achievement and Interest in Science: Evidence from Qatar. *The Journal of Educational Research, 105*(2), 134–146. doi: 10.1080/00220671.2010.533717

Aşıksoy, G., & Islek, D. (2017). The Impact of the Virtual Laboratory on Students' Attitude in a General Physics Laboratory. *International Journal of Online Engineering (Ijoe), 13*(04), 20. https://doi.org/10.3991/ijoe.v13i04.6811

Asselin, M., Branch, J. & Oberg, D. (Eds). (2003). Achieving information literacy standards for school library programs in Canada. O.N: Canadian School Library Association. (atas talian) http://ednet.edc.gov.ab.calk-12/curriculum/by

Atmowardoyo, H. (2018). Research Methods in TEFL Studies: Descriptive Research, Case Study, Error Analysis, and R & D. *Journal of Language Teaching and Research, 9*(1), 197. doi: 10.17507/jltr.0901.25

Babinčáková, M., & Bernard, P. (2020). Online Experimentation during COVID-19 Secondary School Closures: Teaching Methods and Student Perceptions. *Journal of Chemical Education, 97*(9), 3295-3300. doi: 10.1021/acs.jchemed.0c00748

Baker, L., & Cavinato, A. (2020). Teaching Analytical Chemistry in the Time of COVID-19. *Analytical Chemistry, 92*(15), 10185-10186. doi: 10.1021/acs.analchem.0c02981

Bonde, M., Makransky, G., Wandall, J., Larsen, M., Morsing, M., Jarmer, H., & Sommer, M. (2014). Improving biotech education through gamified laboratory simulations. *Nature Biotechnology, 32*(7), 694-697. doi: 10.1038/nbt.2955

Brockman, R., Taylor, J., Segars, L., Selke, V., & Taylor, T. (2020). Student perceptions of online and in-person microbiology laboratory experiences in undergraduate medical education. *Medical Education Online, 25*(1), 1-12. doi: 10.1080/10872981.2019.1710324

Carnevale, D. (2003). The virtual lab experiment some colleges use computer to expand science offerings online. *The Chronicle of Higher education, 49* (21), 30 – 32.

Chahry, A. (2009). *The effect of using virtual laboratories on imparting laboratory experiment skills in the biology course for third-grade secondary students in Jeddah*. (Unpublished master's thesis). Umm Al-Qura University, Saudi Arabia

Chan, C., & Fok, W. (2009). Evaluating learning experiences in virtual laboratory training through student perceptions: a case study in Electrical and Electronic Engineering at the University of Hong Kong. *Engineering Education, 4*(2), 70-75. https://doi.org/10.11120/ened.2009.04020070

Cherner, Y., Cima, M., Barone, P., Dyke, B., & Lotring, A. (2019). Interactive and Adaptable Cloud-based Virtual Equipment and Laboratories for 21st Century Science and Engineering Education. *Epic Series in education science, 3*, 47-53.

Crippen, K., Archambault, L., & Kern, C. (2012). The Nature of Laboratory Learning Experiences in Secondary Science Online. *Research in Science Education, 43*(3), 1029-1050. doi: 10.1007/s11165-012-9301-6

Dagnew, A., & Asrat, A. (2016). Teachers' Perception toward Quality of Education and Their Practice: The Case of Godar Secondary Schools, Ethiopia. *American Journal of Educational Research, 4*(3), 248–253. doi: 10.12691

Daineko, Y., Dmitriyev, V., & Ipalakova, M. (2016). Using virtual laboratories in teaching natural sciences: An example of physics courses in university. *Computer Applications in Engineering Education, 25*(1), 39-47. https://doi.org/10.1002/cae.21777

Daniel, S. (2020). Education and the COVID-19 pandemic. *PROSPECTS, 49*(1-2), 91-96. doi: 10.1007/s11125-020-09464-3

Darrah, M., Humbert, R., Finstein, J., Simon, M., & Hopkins, J. (2014). Are Virtual Labs as Effective as Hands-on Labs for Undergraduate Physics? A Comparative Study at Two Major Universities. *Journal of Science Education and Technology, 23*(6), 803-814. doi: 10.1007/s10956-014-9513-9

Dickson-Karn, N. (2020). Student Feedback on Distance Learning in the Quantitative Chemical Analysis Laboratory. Journal of Chemical Education, 97(9), 2955-2959. https://doi.org/10.1021/acs.jchemed.0c00578

Diwakar, S., Achuthan, K., Nedungadi, P., & Nair, B. (2011). Enhanced Facilitation of Biotechnology Education in Developing Nations via Virtual Labs: Analysis,

Implementation and Case-studies. *International Journal of Computer Theory and Engineering, 12*(2), 1-8. https://doi.org/10.7763/ijcte.2011.v3.275

Education in Qatar Statistical Profile 2016. (2017) (pp. 41-52). Doha - Qatar. Retrieved from https://www.psa.gov.qa/en/statistics/Statistical%20Releases/Social/Education/2016/Education_Statistical_Pro%EF%AC%81le_2016_En.pdf

Espino-Díaz, L., Fernandez-Caminero, G., Hernandez-Lloret, C., Gonzalez-Gonzalez, H., & Alvarez-Castillo, J. (2020). Analyzing the Impact of COVID-19 on Education Professionals. Toward a Paradigm Shift: ICT and Neuroeducation as a Binomial of Action. *Sustainability, 12*(14), 5646. doi: 10.3390/su12145646

Fall 2020 Instructions - Updates | Qatar University. (2021). Retrieved 11 March 2021, from http://www.qu.edu.qa/coronavirus/updated-instructions

Faour, M.A. & Ayoubi, Z. (2018). The effect of using virtual laboratory on grade 10 students' conceptual understanding and their attitudes towards physics. *Journal of Education in Science, Environment and Health (JESEH),* 4(1), 54-68. doi:10.21891/jeseh.387482

Flowers, L. (2011). Investigating the Effectiveness of Virtual Laboratories in an Undergraduate Biology Course. *The Journal of Human Resource and Adult Learning, 7*(2), 110-116. Retrieved from http://www.hraljournal.com/Page/12%20Lawrence%20O.%20Flowers-1.pdf

Gargalakos, M., & Sotiriou, S. (2020). A High-promising Inquiry-based Lab Experience in Electronics Using Remote Labs for Higher Education

Students. *Science Education International*, *31*(4), 418-424. doi: 10.33828/sei.v31.i4.11

General Secretariat for Development Planning, GSDP, (2009). Second human development report of the state of Qatar. Doha: Qatar.

Ghaith, M. (2017). The use of virtual labs by middle school science teachers and their attitudes towards them. *The International Interdisciplinary Journal of Education (IIJE), 6(5),* 39-53

Gillet, D., Jong, T., Sotirou, S., & Salzmann, C. (2013). Personalised Learning Spaces and Federated Online Labs for STEM Education at School. *In 2013 IEEE Global Engineering Education Conference (EDUCON)* (pp. 769-773). Berlin; IEEE Xplore.

Hassanein, E. E. (2010). *The inclusion of children with special educational needs in mainstream schools in Egypt* (Doctoral thesis). Exeter University, UK.

Heintz, M., law, E., Manoli, C., Zacharia, Z., & Riesen, S. (2015). A Survey on the Usage of Online Labs in Science Education: Challenges and Implications. *In 2015 IEEE Global Engineering Education Conference (EDUCON)* (pp. 827-835). Tallinn; IEEE Xplore.

Hejaze, R. (2018). Qatar's Performance in International Tests: PIRLS, TIMSS, PISA and TOEFL. Retrieved 7 April 2020, from https://sites.northwestern.edu/qtaaleam/qatars-performance-in-international-tests/#.Xo1hWohKg2w

Hernández-de-Menéndez, M., Vallejo Guevara, A., & Morales-Menendez, R. (2019). Virtual reality laboratories: a review of experiences. *International Journal on Interactive Design and Manufacturing (Ijidem)*, 13(3), 947-966. doi: 10.1007/s12008-019-00558-7

Husain, H. (2013). *The effectiveness of using the virtual laboratory in science teaching to correct wrong perceptions of some scientific concepts and develop habits of mind among second-grade middle school students*. (Unpublished master's thesis in science curriculum and instructions). College of Education, Sohag University

Hyder, A., Choi, S., & Schaefer, D. (2010). Remotely controlled laboratory experiments: Creation and examples. *2010 IEEE Systems and Information Engineering Design Symposium.* https://doi.org/10.1109/sieds.2010.5469676

Laronde, G., & MacLeod, K. (2012). Modeling Various Teaching Methods in a Faculty of Education in Science Education: Chalk and Talk, Virtual Labs or Hovercrafts. *Journal of College Teaching & Learning (TLC), 9*(2), 107-114. https://doi.org/10.19030/tlc.v9i2.6905

Ling, W., Lee, T., & Tho, S. (2017). A technological acceptance of remote laboratory in chemistry education. *Asia-Pacific Forum on Science Learning and Teaching, 18*(2). Retrieved from https://www.researchgate.net/publication/324030259_A_technological_acceptance_of_remote_laboratory_in_chemistry_education

Liu, D., Valdiviezo-Díaz, P., Riofrio, G., Sun, Y., & Barba, R. (2015). Integration of Virtual Labs into Science E-learning. *Procedia Computer Science*, 75, 95-102. doi: 10.1016/j.procs.2015.12.224

Lynch, T., & Ghergulescu, I. (2017). NEWTON Virtual Labs: Introduction and Teacher Perspective. *2017 IEEE 17Th International Conference on Advanced Learning Technologies (ICALT)*. https://doi.org/10.1109/icalt.2017.133

Machira, s. (2017). *Students' characteristics, teachers' perceptions and achievement in science subjects among students in public secondary schools in Laikipia county, Kenya.* (Master of Education). Kenyatta University.

Mogra, S., & Furlan, R. (2017). Public Realm at Qatar University Campus: Perception and sustainability of Open Green Spaces. *Saudi Journal of Humanities and Social Sciences*, *2*(1), 80-94. doi: 10.21276/sjhss.2017.2.1.13

Nassaji, H. (2015). Qualitative and descriptive research: Data type versus data analysis. *Language Teaching Research*, *19*(2), 129-132. doi: 10.1177/1362168815572747

Omar, Y. (2014). *The effect of using the virtual laboratory for science experiments in developing science processes and acquiring concepts among fifth grade female students in Palestine.* (Master of Science Teaching Methods at the College of Graduate Studies). An-Najah National University.

Qiang, Z., Guillen, A., Chen, Y., & Ye, C. (2020). Revisiting Distance Learning Resources for Undergraduate Research and Lab Activities during COVID-19 Pandemic. *Journal of Chemical Education*, *97*(9), 3446–3449. doi: https://doi.org/10.1021/acs.jchemed.0c00609

Ray, S., & Srivastava, S. (2020). Virtualization of science education: a lesson from the COVID-19 pandemic. *Journal of Proteins and Proteomics, 11*(2), 77-80. doi: 10.1007/s42485-020-00038-7

Richer, R. (2014). Sustainable development in Qatar: Challenges and opportunities. *Qscience Connect, 2014*(1), 1-14. doi: 10.5339/connect.2014.22

Rowe, R., Koban, L., Davidoff, A., & Thompson, K. (2017). Efficacy of Online Laboratory Science Courses. *Journal of Formative Design in Learning, 2*(1), 56-67. doi: 10.1007/s41686-017-0014-0

Safaah, E., Muslim, M., & Liliawati, W. (2017). Teaching Science Process Skills by Using the 5-Stage Learning Cycle in Junior High School. *Journal of Physics: Conference Series*, 895, 1-6. doi: 10.1088/1742-6596/895/1/012106

Said, Z. (2011). 'Qatari Students' Interest in Attitudes toward Science: The Impact of the Educational Reform on Science Education in Qatar. *Qatar Foundation Annual Research Forum Proceedings*, (2011). doi: 10.5339/qfarf.2011.aho4

Said, Z., & Friesen, H. (2013). Qatari students performance, interest in, and attitude towards science and mathematics. *European Scientific Journal*. Retrieved from https://www.researchgate.net/publication/260224767_QATARI_STUDENTS_PERFORMANCE_INTEREST_IN_AND_ATTITUDE_TOWARDS_SCIENCE_AND_MATHEMATICS

Saleh, M. (2013). Study the possibility of implementing a virtual learning environment in educational institutions. *Journal of Baghdad College of Economic sciences University,* College Conference Special Issue, 4-475

Salter, S., & Gardner, C. (2016). Online or Face-to-Face Microbiology Laboratory Sessions? First Year Higher Education Student Perspectives and Preferences. *Creative Education, 7*(14), 1869-1880. doi: 10.4236/ce.2016.714189

Sequeira, A. (2012). Introduction to Concepts of Teaching and Learning. *SSRN Electronic Journal.* doi: 10.2139/ssrn.2150166

Si'ayah, S., Kurniawati, N., Velasufah, W., & Setiawan, A. (2019). A Brief Explanation of Basic Science Education, 1-12. doi: 10.35542/osf.io/z62w8

Stuckey-Mickell, T., & Stuckey-Danner, B. (2007). Virtual Labs in the Online Biology Course: Student Perceptions of Effectiveness and Usability. *MERLOT Journal of Online Learning and Teaching, 3*(2), 105-111.

Suliman, Z. (2018). The practice of teaching Arabic between teaching and learning. Journal of Studies and Research, *30*(9), 36-46. Retrieved from: http://search.mandumah.com/Record/875428

Sypsas, A., and Kalles, D. (2018). Virtual Laboratories in Biology, Biotechnology and Chemistry education: A Literature Review. *In Proceedings of PCI '18, November 29-December 1, 2018, Athens, Greece, 6 pages.* https://doi.org/10.1145/3291533.3291560

Taha, H. (2016). The effectiveness of using the virtual laboratory in the achievement of practical physical chemistry and the tendency towards it among students of the College of Education. *Journal of Kufa Studies Center, 41*, 287-336

Taherdoost, H. (2016). Sampling Methods in Research Methodology; How to Choose a Sampling Technique for Research. *SSRN Electronic Journal*. doi: 10.2139/ssrn.3205035

Tambaya, S., SABITU, A., & Matazu, Y. (2016). Comparative Analysis of Gender Performances in Biology, Chemistry and Physics among Pre-Degree Students of Federal University, Dutsinma. *International journal of educational benchmark (IJEB)*, 5(1), 108-118.

Theqa, H. (2011). Attitudes of chemistry teachers and supervisors towards using virtual laboratory technology and some of their demands in the city of Makkah Al-Mukarramah. (Unpublished master's thesis), Umm Al-Qura University, College of education, curriculum and instructions.

Ursachi, G., Horodnic, I., & Zait, A. (2015). How reliable are Measurement Scales? External Factors with Indirect Influence on Reliability Estimators. *Procedia Economics and Finance, 20*, 679-686. doi: 10.1016/s2212-5671(15)00123-9

Virtual Reality Lab | Qatar University. (2021). Retrieved 11 March 2021, from http://www.qu.edu.qa/offices/Information-Technology-Services/Virtual-Reality-Lab-for-Research-and-Education

Vishal, D., & Aarti, Y. (2016). Constructivism: A Paradigm for Teaching and Learning. *Arts and Social Sciences Journal, 7*(4). doi: 10.4172/2151-6200.1000200

Wang, C. Y., Wu, H. K., Wen-Yu Lee, S., Hwang, F. K., Chang, H. Y., Wu, Y. T., Lo, H. C. (2014). A review of research on technology-assisted school science laboratories. *Journal of Educational Technology & Society, 17*(2), 307–320.

Wei, B., & Li, X. (2017). Exploring science teachers' perceptions of experimentation: implications for restructuring school practical work. *International Journal of Science Education, 39*(13), 1775-1794. doi: 10.1080/09500693.2017.1351650

Wei, J., Treagust, D., Mocerino, M., Lucey, A., Zadnik, M., & Lindsay, E. (2019). Understanding interactions in face-to-face and remote undergraduate science laboratories: a literature review. *Disciplinary and Interdisciplinary Science Education Research, 1*(1). doi: 10.1186/s43031-019-0015-8

Youssef, H. (2019). *Biology teaching materials and their orientation towards using the virtual laboratory in teaching practical experiences for secondary school learners in the State of Kuwait*. *(*Unpublished master's thesis), Kuwait University, Kuwait.

Zhang, W., Wang, Y., Yang, L., & Wang, C. (2020). Suspending Classes Without Stopping Learning: China's Education Emergency Management Policy in the COVID-19 Outbreak. *Journal of Risk and Financial Management, 13*(55), 1-6. doi: 10.3390/jrfm13030055

Zupanc, G., Lehotzky, D., & Tripp, I. (2021). The Neurosphere Simulator: An educational online tool for modeling neural stem cell behavior and tissue growth. *Developmental Biology, 469*, 80-85. doi: 10.1016/j.ydbio.2020.09.016

APPENDIX

Appendix (A): Questionnaire first draft

Questionnaire of

Perceptions of Undergraduate Students, Lecturers, and Lab Assistants towards the Use of Online Laboratory in Science during Covid-19 Pandemic

Dear participants this questionnaire aimed to investigate the undergraduate students', lecturers', and lab assistants' perceptions towards the use of online laboratory in Chemistry, Physics, and Biology at Qatar University and discover the differences attributed to the gender, role, and nature of the subject of the participants during the exceptional period of covid-19. Therefore, your responses are very important to achieve the aim of the study.

Your cooperation is highly appreciated.

Demographics

1- **Gender: (Male/Female)**
الجنس: (ذكر/ أنثى)

2- **Which science laboratory you are involved in?**
(Chemistry/ Physics/ Biology)
أي مختبر للعلوم انت ملتحق به؟
(كيمياء/ فيزياء/ أحياء)

3- **What is your role in Qatar University?**
(Student/ Lecturer/ Lab assistant)
ما هو دورك في جامعة قطر؟
(طالب/ محاضر/ مساعد مختبر)

NO	ITEM **Online science lab:** **مختبر العلوم الافتراضي:**	Likert scale				
		5 Strongly Agree موافق بشدة	4 Agree موافق	3 Neutral محايد	2 Disagree غير موافق	1 Strongly Disagree غير موافق بشدة
Perceived Usefulness (PU)						
1	**provides a good integration of technology** **يوفر تكامل جيد مع التكنولوجيا**					
2	**provides safe environment for experiments** **يعد بيئة آمنة لإجراء التجارب**					
3	**helps in modeling abstract concepts** **يساعد في تجسيد المفاهيم المجردة**					
4	**supports individual learning** **يدعم التعلم الفردي**					
5	**provides online immediate feedback for students** **يوفر تغذية راجعة فورية عن بعد للطلاب**					
6	**improves students' performance in science** **يحسن من أداء الطلاب في العلوم**					

7	**helps students in remembering science concepts** **يساعد الطلاب في تذكر المصطلحات الخاصة بالعلوم**					
8	**increases students' engagement in the learning process** **يزيد من اندماج الطلاب في العملية التعليمية**					
9	**makes data analysis easier.** **يسهل عملية تحليل البيانات**					
10	**helps in interpreting data** **يساعد في عملية تفسير البيانات**					
11	**helps students in answering questions that puzzle them.** **يساعد في الإجابة على الأسئلة التي تحير الطلاب**					
12	**makes students miss the practical experience of the real lab.** **يفقد الطلاب التجربة العملية للعمل في المختبر الواقعي**					
13	**increases the plagiarism rate in the lab activities** **يزيد من نسبة الاقتباس في الأنشطة المخبرية**					

14	**prevents direct interaction with the teacher** **يمنع التواصل المباشر مع المعلم**					
15	**prevents direct interaction with colleagues** **يمنع التواصل المباشر مع الزملاء**					
16	**prevents students from learning how deal with lab instruments and devices (manual work skills)** **يمنع الطلاب من تعلم طرق التعامل مع الأدوات والأجهزة المخبرية (مهارات العمل اليدوية)**					
Perceived Ease of Use (PEOU)						
17	**reduces the time required to conduct experiments** **يختصر من الوقت اللازم لإجراء التجارب**					
18	**provides a virtual environment rich in devices, equipment, and tools for experiments.** **يوفر بيئة افتراضية غنية بالأجهزة والمعدات والادوات اللازمة للتجارب.**					
19	**makes getting help from the teacher difficult**					

	يجعل الحصول على المساعدة من قبل المعلم أمر صعب					
20	needs specific programs يحتاج إلى برامج محددة					
21	There is a difficulty in taking measurements accurately يوجد صعوبة في أخذ القياسات بدقة					
22	Technical issues present a problem while working in the laboratory تمثل المسائل التقنية مشكلة أثناء العمل في المختبر					
23	makes the assessment process difficult تجعل عملية التقييم صعبة					
24	makes the equipment's preparation process easier تجعل عملية التحضير من حيث المعدات أمر سهل					
Attitude toward Use (ATU)						
25	provides an interactive environment يوفر بيئة تفاعلية					
26	provides a motivational environment يوفر بيئة محفزة					

27	**provides a comfortable environment.** **يوفر بيئة مريحة**					
28	**is a simulation equivalent to the real lab.** **يعد محاكاة مشابهة تماما بالواقع**					
29	**provides an opportunity for creative research work** **يوفر فرصة جيدة للابتكار في مجال البحث**					
30	**provides an enjoyable methods of learning science** **يوفر طرق ممتعة لتعلم العلوم**					
31	**will increase the students' motivation to learn science** **يزيد من دافعية الطلاب لتعلم العلوم**					
32	**I can work faster on the experiments online** **أستطيع العمل أسرع خلال التجارب الافتراضية**					
33	**I think I will use it frequently when I have access to it** **اعتقد بأني سأستخدمه بشكل متكرر عندما احصل على صلاحية الدخول إليه**					

34	**I feel frustrating during using the online lab** **اشعر بالإحباط أثناء العمل في المختبر الافتراضي**					
35	**I am just a viewer during the online lab** **أنا فقط مشاهد أثناء المختبر الافتراضي**					
Behavioral Intention (BI)						
36	**I look forward to the activities that will be used in the online science laboratory.** **أتطلع قدما للنشاطات التي ستستخدم في المعمل الافتراضي**					
37	**I plan to use it in the future** **أتطلع لاستخدامه في المستقبل**					
38	**I prefer to use it in the future simultaneously with the real laboratory** **أفضل استخدامه في المستقبل متزامنًا مع المختبر الواقعي**					

Appendix (B): Questionnaire final draft

Questionnaire of

Perceptions of Undergraduate Students, Lecturers, and Lab Assistants towards the Use of Online Laboratory in Science during Covid-19 Pandemic

Instructions: this questionnaire will investigate the undergraduate students', lecturers', and lab assistants' perceptions towards the use of online laboratory in Chemistry, Physics, and Biology at Qatar University during the exceptional period of covid-19. Online laboratory is defined in this study as: using of technology to conduct simulated experiments in Chemistry, Physics or Biology. It will take 15 minutes to answer the questionnaire, your responses will be kept confidential and it will not affect you. If you have any question regarding the questionnaire, you can contact the researcher: me1507361@qu.edu.qa

Demographics

1- **Gender: (Male/Female)**
الجنس: (ذكر/ أنثى)

2- **Which science laboratory you are involved in?**
(Chemistry/ Physics/ Biology)
أي مختبر للعلوم انت ملتحق به؟
(كيمياء/ فيزياء/ أحياء)

3- **What is your role in Qatar University?**
(Student/ Lecturer/ Lab assistant)
(طالب/ محاضر/ مساعد مختبر)

All the statements below are related to your opinion about the online science labs.

Indicate your level of agreement with each statement.

NO	ITEM I agree that Online science lab: أوافق أن مختبر العلوم الافتراضي:	Likert scale				
		5 Strongly Agree موافق بشدة	4 Agree موافق	3 Neutral محايد	2 Disagree غير موافق	1 Strongly Disagree غير موافق بشدة
Perceived Usefulness (PU)						
1	provides a good integration of technology يوفر تكامل جيد مع التكنولوجيا					
2	provides safe environment for experiments يوفر بيئة آمنة لإجراء التجارب					
3	helps in modeling abstract concepts يساعد في تجسيد المفاهيم المجردة					
4	supports individual learning يدعم التعلم الفردي					
5	provides immediate feedback for students يوفر تغذية راجعة فورية عن بعد للطلاب					
6	improves students' performance in science يحسن من أداء الطلاب في العلوم					

7	helps students in understanding science concepts يساعد الطلاب في فهم المصطلحات الخاصة بالعلوم					
8	increases students' engagement in the learning process يزيد من اندماج الطلاب في العملية التعلّمية					
9	makes data analysis easier يسهل عملية تحليل البيانات					
10	helps students in answering questions that puzzle them يساعد في الإجابة على الأسئلة التي تحير الطلاب					
11	makes students miss the practical experience of the real lab يفقد الطلاب التجربة العملية للعمل في المختبر الواقعي					
12	increases the plagiarism rate in the lab activities يزيد من نسبة الانتحال في الأنشطة المخبرية					
13	limits direct interaction with the teacher يحد التفاعل المباشر مع المعلم					
14	limits direct interaction with colleagues يحد التفاعل المباشر مع الزملاء					

15	Limits the development of manual laboratory work skills (handling laboratory materials, tools, and instruments) يحد من تنمية مهارات العمل المخبري اليدوية (التعامل مع المواد والأدوات والأجهزة المخبرية)					
16	limits the teamwork يحد من العمل الجماعي					
Perceived Ease of Use (PEOU)						
17	provides flexibility in choosing the time and place يوفر مرونة في اختيار الزمان والمكان					
18	requires a lot of special technical training التقني الخاص يحتاج الكثير من التدريب					
19	needs specific programs like: (LabXchange – Labster) يحتاج إلى برامج محددة مثل: (LabXchange – Labster)					
20	There is a difficulty in getting measurements accurately يوجد صعوبة في أخذ القياسات بدقة					
21	Technical issues present a problem while working in the laboratory					

	تمثل المسائل التقنية مشكلة أثناء العمل في المختبر					
22	makes the lab work assessment difficult يصعب عملية تقييم العمل المخبري					
23	makes the preparations needed for the experiment easier يسهل عملية تحضير المعدات للتجارب					
Attitude toward Use (ATU)						
24	provides an interactive and motivational environment ومحفزة يوفر بيئة تفاعلية					
25	provides simulation equivalent to the real lab. يوفر محاكاة مشابهة تماما للواقع					
26	provides an opportunity for creative research work يوفر فرصة جيدة للابتكار في مجال البحث					
27	increase the students' motivation to learn science يزيد من دافعية الطلاب لتعلم العلوم					
28	I can work faster on the experiments online أستطيع العمل أسرع خلال التجارب الافتراضية					
29	I will use it more frequently when there is access to it اعتقد بأني سأستخدمه بشكل متكرر عندما يكون ذلك متاحا					

30	I feel frustrating during using the online lab اشعر بالإحباط أثناء العمل في المختبر الافتراضي					
31	My role is limited to watching only during the online lab يقتصر دوري على المشاهدة فقط أثناء المختبر الافتراضي					
Behavioral Intention (BI)						
32	I am not planning to use it in the future لا أتطلع لاستخدامه في المستقبل					
33	I prefer to use it in the future simultaneously with the real laboratory أفضل استخدامه في المستقبل متزامنًا مع المختبر الواقعي					
34	I will suggest improvements to it for the future use سأقترح تحسينات لاستخدامه مستقبلا					
35	I look forward learn more about it أتطلع الى معرفة المزيد عنه					
36	I will seek to participate and attend forums and conferences related to online laboratories					

	سأسعى للمشاركة وحضور المؤتمرات المتعلقة بالمختبرات الافتراضية					

Appendix (C): List of the specialists reviewed the questionnaire

No.	Name	Academic degree	Work position
1	Prof. Xiangyun Du	Professor in Educational Sciences, In Problem and Project Based Learning	Department of Educational Sciences, the College of Education, Qatar University
2	Prof. Ahmed Jassim Y Al-Saai	Professor in Educational Sciences	Department of Educational Sciences, the College of Education, Qatar University
3	Prof. Asma Abdulla M Al-Attiyah	Professor in Psychological Sciences	Department Head of Psychological Sciences, the College of Education, Qatar University
4	Prof. Aisha Ahmed M S Fakhro	Professor in Educational Sciences	Associate Dean for Academic Affairs, College of Education, Qatar University
5	Prof. Sobhi H. M. Abujalala	Professor in Educational Sciences	Department of Educational Sciences, the College of Education, Qatar University
6	Dr. Elsayed Elshabrawi A. Hassanein	Associate Professor of Psychological Sciences	Coordinator of Graduate Programs in the Psychological Sciences
7	Dr. Diala Abdul Hadi Hamaidi	Associate Professor of Psychological Sciences	Department of Psychological Sciences, the College of Education, Qatar University
8	Dr.Saba Mansoor Qadhi	Assistant Professor in educational sciences	Associate Director of Core Curriculum

			Program, Deanship of General Studies
9	Mr.Naeem Othman Balasmeh	Masters in Atomic physics	Senior Professional Development Specialist (science), National Center for Educational Development, Qatar University
10	Magdy Ragab Ismail	Professor of Science Curricula and Teaching Methods	College of Education, Ain Shams University
11	Shaimaa Mohamed Ahmed	Professor of Science Curricula and Teaching Methods	College of Education, Ain Shams University
12	Heba Fouad Ahmed Elsayed	Professor of Science Curricula and Teaching Methods	College of Education, Ain Shams University