A Comparison of Students' Learning Experience in Undergraduate Engineering Programs Using Face-to-Face and Synchronous

Albertus Retnanto, Ph.D.
Professor, Petroleum Engineering
Texas A&M University at Qatar
Doha, Qatar
albertus.retnanto@qatar.tamu.edu

Hamid R. Parsaei, Ph.D., P.E.
Professor, Industrial and Systems Engineering
Texas A&M University
College Station, TX, USA
hamid.parsaei@tamu.edu

Boback Parsaei
Vice President and Chief Technical Officer
Integrated Technology Systems, Inc.
Houston, Texas, USA
bobackparsaei@outlook.com

Abstract

The availability of high-speed internet systems and more advanced digital mediums provided better opportunities for transforming knowledge and aiding teaching and learning over the past decade. Academic institutions have been encouraging and incentivizing their faculty to collaborate with the technical staff to utilize digital technology in the classrooms and to report and present their challenges. With the arrival of the COVID pandemic in early 2020, institutions rushed to use digital mediums to transform their delivery methods from face-to-face or in-person to synchronous or asynchronous, depending on the institution's readiness. Texas A&M University and one of its two satellite campuses in Qatar adopted the same policy. Texas A&M University is one of the few universities successfully establishing an international campus. The Qatar campus started its operation in the fall of 2002. Since its inception, the campus has offered four ABET-accredited engineering programs in chemical, electrical, mechanical, and petroleum engineering, and by May 2022, over 1,300 received engineering degrees. The campus has consistently been well regarded for its innovative approaches to teaching and learning methods in the Middle East and North Africa (MENA Region). This article presents the results of an empirical study conducted at Texas A&M University in Qatar and Texas A&M University in College Station, Texas, in two undergraduate courses taught on these two campuses. This study also compared students' participation and academic performance during remote in-class (synchronous) and face-to-face learning.

Keywords

Delivery Methods, Effectiveness of online instructions, Face-to-face learning, Remote teaching and learning ability, Synchronous instructions.

1. Introduction

The majority of the Gulf Countries (countries bordering the Persian Gulf) have created strategies to raise living standards and convert their fossil fuel-based economies to knowledge-based economies over the previous three decades. Education, particularly Western education, is one of the primary foundations of these nations' vision. In a

number of instances, the governing organizations invited a few internationally renowned colleges to establish an official branch in the nation and entice the next generation to seek Western education (Retnanto et al., 2022; Retnanto et al., 2012; Retnanto et al., 2020). Texas A&M University is one of few United States-based Institutions that established a formal academic unit outside of the country. The Texas A&M University-Qatar campus first was realized in 2002 and the first cohorts received their diploma in May 2008. Texas A&M University at Qatar offers four ABET-accredited engineering degrees in the Chemical, Electrical, Mechanical, and Petroleum disciplines. The academic curricula for these programs are identical to those offered in the main campus in College Station, Texas and diplomas are also issued by the main campus. Since 2008, over 1,300 successfully completed the degree requirements and diplomas were bestowed upon them.

Texas A&M University Qatar campus is physically located in the Hamed Bin Khalifa University (HBKU) facilities which are financially supported by Qatar Foundation. Qatari citizens historically make up fifty percent of the enrollments and the rest are made up of non-Qatari students whose parents or siblings reside in Qatar and who hold temporary residency permits to stay in the country. Texas A&M University-Qatar campus faculty is comprised of faculty from College Station who express the desire to temporally relocate to Qatar or people with terminal degrees hired exclusively to provide instructional services at the location. All engineering programs have been successfully reviewed and accredited by ABET on three different occasions since 2008. The instructional language at Texas A&M University-Qatar campus is English and all admitted to engineering programs possess high proficiency in English.

Qatar is one of the smallest countries in the world. This peninsula is surrounded by the Persian Gulf and it is connected by land to the Kingdom of Saudi Arabia. Qatar's population in 2023 was estimated at about 3 million and it's native makes up about 15% of the total population and the rest are expatriates working for various entities in the country. As of 2022, Qatar has the fifth highest GDP per capita in the world, according to the International Monetary Fund. Although, Arabic is the official language in the country, a large percentage of the population is fluent in English. The late 1990s saw the adoption of Qatar's Vision 2030, which focuses on the capacity development of its populace. One of the few nations in the world that has invested much in establishing some of the greatest standards of life and encouraging higher education among its youth is Qatar (Qatar National 2015; Toth 1993; Magee 2014; Commins 2021; Retnanto et al., 2022). Qatar has made major investments in creating and implementing cutting-edge infrastructure since 2010, including highways, high-speed communication networks, airports, banking, and commerce.

2. Background

The arrival of the COVID virus, political decisions to stop its spread by closing all public gathering places, including schools, public transportation, places of worship, etc., as well as a general lack of knowledge about how to handle and manage the pandemic and its enormous transmission rate put an end to the operations of the international community. By using readily available mass communication methods like Zoom, SKYPE, and other tools, the majority of academic institutions elected to continue the Spring 2020 academic session after extending their spring breaks. Most academic institutions chose to adopt these systems as an alternative to face-to-face instructional techniques despite the fact that many of these tools had not been thoroughly tested and their limitations had not been thoroughly explored in the past. Contrary to many Western nations, Qatar has started using 5G speed communication technologies in 2018. These multimedia systems were used to instruct faculty, staff, and students throughout all Texas A&M University campuses, including those in College Station and Qatar. The College Station, Texas campus of Texas A&M University and the TAMU campus in Qatar transitioned to entirely online learning using multimedia resources.

3. Methods

The study compares traditional face-to-face methods of teaching and learning with online in-class instruction. For this reason, the authors offered a brief survey (screened and approved by the Texas A&M University, College Station campus, Human Research Protection Program) asking students about their experiences enrolling in face-to-face and online classes. Twenty questions made up the questionnaire, which included the fundamental demographics, benefits, and drawbacks of in-person instruction versus online instruction, as well as distant access to the course materials (Retnanto et al., 2022). Students majoring in petroleum engineering were chosen for the study. The Texas A&M University campus in College Station provided one undergraduate course, ISEN 210 - Introduction to Industrial and Systems Engineering Design. The two sections of ISEN 210 that participated in this study were conducted by undergraduate petroleum students in the same academic semester, in the spring of 2021. (Retnanto et al., 2022).

4. Data Collection

A brief survey was distributed to students asking about their experiences enrolling in face-to-face and online classes. Twenty questions made up the questionnaire. Students who took part in the survey are listed in Table 1. The empirical investigation in this paper received responses from 129 students in total.

Table 1. Student Enrollments

Course	Females	Males	Total Students
ISEN 210 – Section 1	17	31	48
ISEN 210 – Section 2	13	35	48
Petroleum Engineering Students	21	12	33

Table 2 displays the distribution of student levels from sophomore to senior. ISEN 210 is offered during the academic semester in a number of sections.

Table 2. Student Classification

Course	Sophomore	Junior	Senior	Total
ISEN 210 – Section 1	10	35	3	48
ISEN 210 – Section 2	22	25	1	48
Petroleum Engineering Students	13	7	13	33

Figures 1 to 5 show the data collection of surveys where the left figure represents male students and the right figure for female students. The level of student proficiency in information technology is shown in Figure 1. The majority of students in ISEN 210 sections 1 and 2 rated their IT skills as "moderate" for both males and females. And in both areas, almost 80% have a moderate or high level. The level of student proficiency is the same for petroleum engineering students at the Qatar campus. All Petroleum Engineering students rated their IT proficiency as moderate to high at the same time. The majority of the Z generation is accustomed to the virtual online approach available for group communication thanks to a more dependable high-speed internet connection.

Figure 2 shows the percentage of students that have participated in any type of synchronous learning. The majority of students in ISEN 210 sections 1 and 2 have participated in remote learning for both male and female students. While less than 35% of Qatar Campus petroleum engineering students have learned thru synchronous learning.

The benefits of distance learning for undergraduate students are depicted in Figure 3 (synchronous learning). The greatest benefits of online classes were those that allowed access to online materials. At the same time, Qatar Campus petroleum engineering students emphasized the similar benefits of using online resources and feeling comfortable in the learning environment. In addition, all students felt that they have the ability to record a course and have access to the class recording material. Providing online course materials is one of the advantages that has been learned during COVID time and should be continued. The requirement for online access to course materials and resources was the most important motif we found. The respondents showed a desire for more access to class/lecture notes and slides, assignments, examinations, and quizzes, as well as lectures that have been recorded or are currently being streamed. Students stressed the significance of teachers adopting or enhancing their usage of the institution's Learning Management System, as well as having course materials structured for simple navigation and use in the online learning environment. Students on both campuses agree that class interactivity is the least advantage of remote learning.

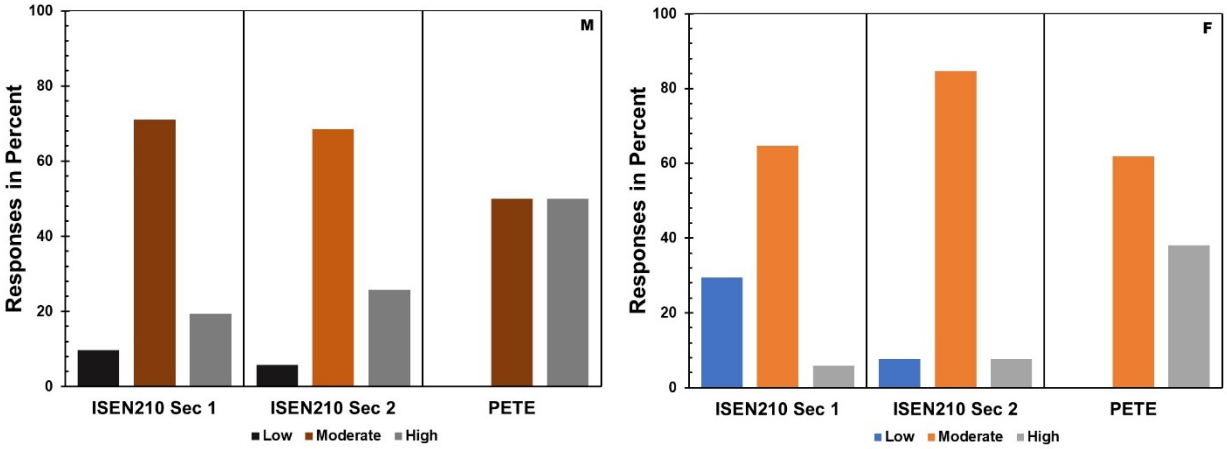

Figure 1. Students' level of information technology (IT) skills

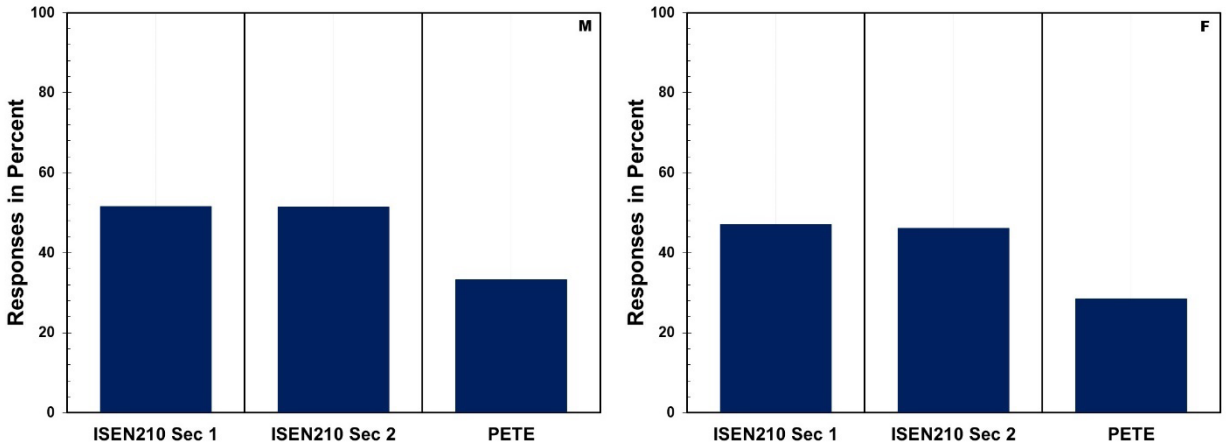

Figure 2. Student Participation in any type of synchronous (class remotely)

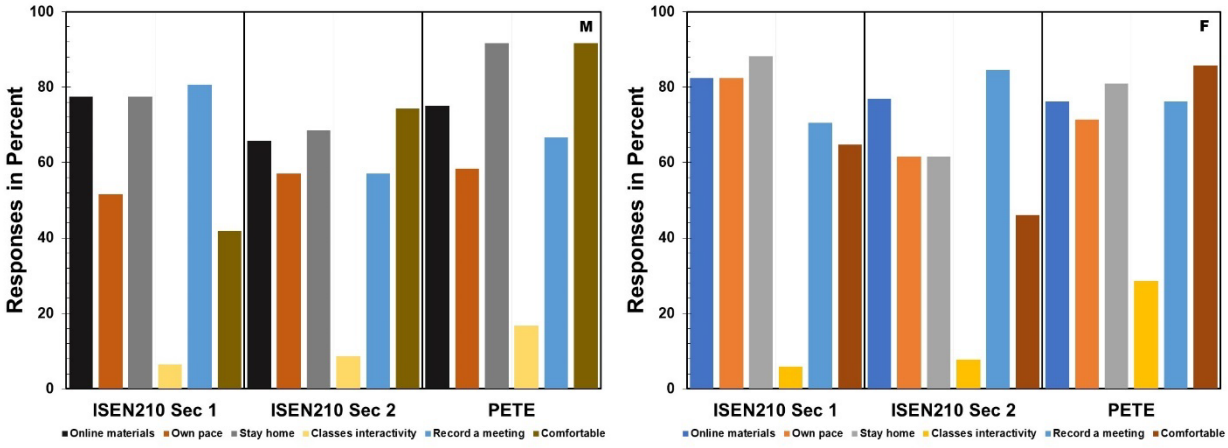

Figure 3. Advantages of Participating in Class Remotely (synchronous learning)

Figure 4 illustrates the drawback of attending class remotely (synchronous learning). The main disadvantage was a result of interactions with the teacher and other pupils. In sections 1 and 2 of ISEN 210, almost 83% of students and 64% of petroleum undergraduate students chose "reduced interaction with the teacher" as the main drawback for both male and female students. Some students find it challenging to concentrate in online classes since there is less face-to-face interaction. Students lose the sense of urgency and drive they require to arrive to class on time, fulfill deadlines, and advance when teachers or classmates are physically absent. The "technical problems" were considered by almost 100% of female petroleum engineering students to be the main drawbacks of synchronous learning. Having 5G speed communication technologies, unfortunately, in a world where everything is done online, technical problems will inevitably arise.

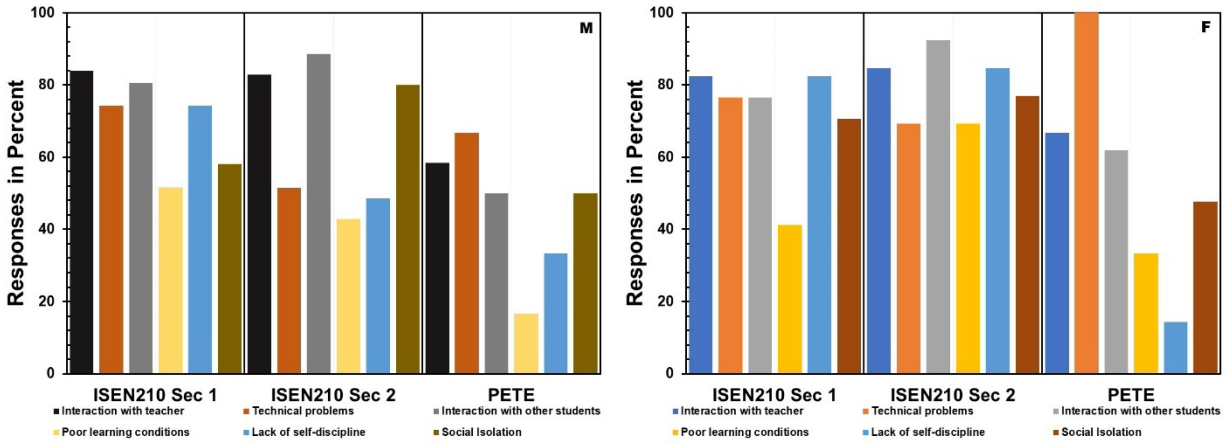

Figure 4. Disadvantages of Participating in Class Remotely (synchronous learning)

Figure 5 illustrates the logistical difficulties of participating in a class remotely. For students taking ISEN 210 sections 1 and 2, as well as those taking TAMUQ, the importance of quiet, private study space and a dependable internet connection is among the highest for both male and female students. More than 50% of students enrolled in ISEN 210, sections 1 and 2, cited the stable internet or remote connection as the most logistical problem. Students who were studying petroleum engineering (50%) gave similar answers. Female students in the Qatar campus considered reliable internet is the highest challenge and this is consistent with the technical problem faced for their class participation remotely. Students on both campuses felt that their computers/laptops/tablets were sufficient to support remote classes and be the least logistical challenges. The university requires students to have access to a suitable computer in order to supplement course instruction due to the changes in higher education including the integrated webcam and Wi-Fi capability. The higher education environment has seen a significant transformation as a result of the COVID-19 epidemic, which has increased the use of technology in classroom instruction. All students need to have a suitable computer to guarantee they can participate completely in-class work, just as we demand all of our students to have specified textbooks and supplies in order to receive the greatest quality educational experience.

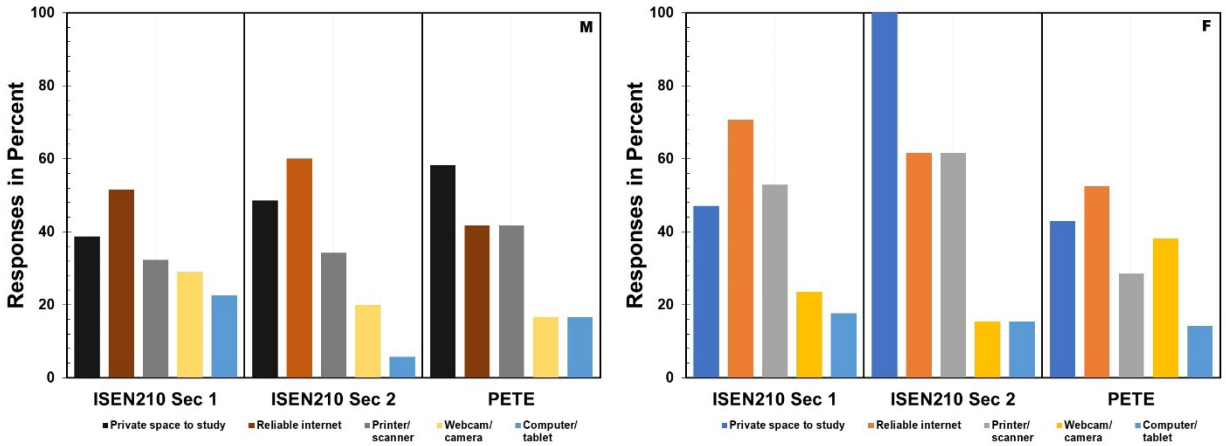

Figure 5. Logistical Challenges of Participating in Class Remotely

5. Results and Discussion

Figures 6 to 11 show the data collection of surveys where the left figure represents male students and the right figure for female students.

When students were questioned about the usefulness of participating in class remotely in terms of enhancing communication skills, one of the survey's key findings was revealed (Figure 6). Over 60% of participants in ISEN 210 sections 1 and 2 believed that attending class remotely had little to no effect on improving communication skills, respectively for both male and female students. On the Qatar campus, only 40% of the petroleum engineering students reached the same conclusions. Additionally, less than 23% of ISEN 210 students in section 1 and section 2 concluded that in-class, synchronous remote instruction was effective or extremely effective, in contrast to more than 33% of petroleum undergraduate students in Qatar who reached the same conclusion.

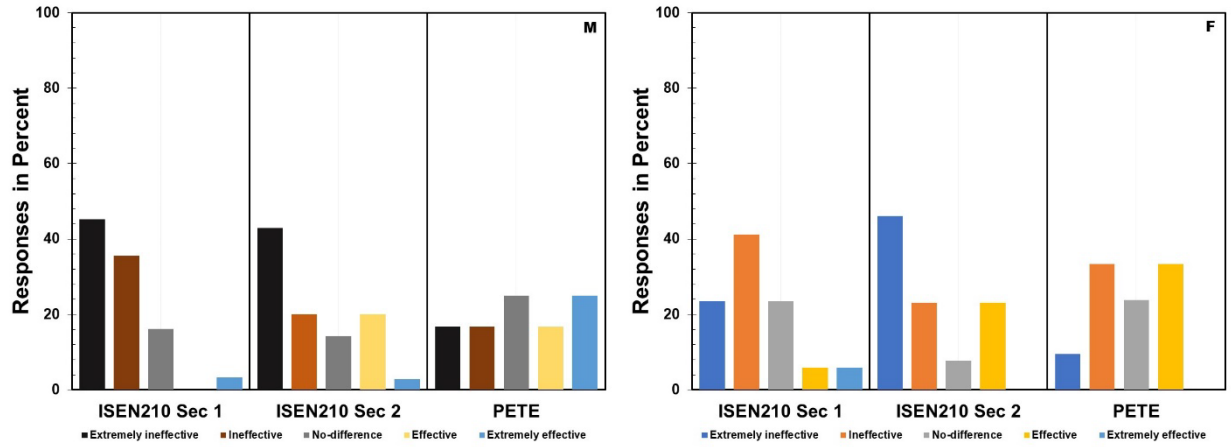

Figure 6. Effectiveness of Participating in Class Remotely in Terms of Increasing Communications Skills

In terms of enhancing communication skills, students contrast active participation in class with traditional face-to-face interaction (Figure 7). In the ISEN 210 sections 1 and 2, only an average of 8% of students believed that engaging in class using the traditional face-to-face method had little to no influence on improving communication skills. All female students of petroleum engineering at the Qatar site reached the same findings, which is a comparable outcome. Additionally, more than 80% of students enrolled in the ISEN 210 found traditional face-to-face effective or extremely effective in sections 1 and 2 for both male and female students, in contrast to an average of 60% of petroleum undergraduate students in Qatar who came to the same conclusion.

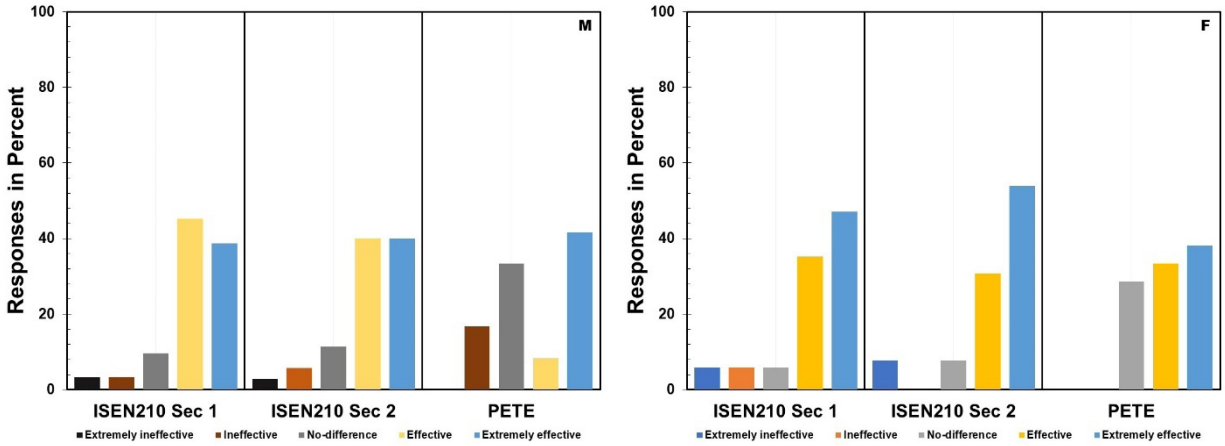

Figure 7. Effectiveness of Traditional Face-to-Face Learning in Terms of Increasing Communications Skills

The survey findings when students were asked to rate the efficiency of taking part in class remotely (synchronous learning) in terms of developing theoretical knowledge are shown in Figure 8. Over 50% of respondents to the ISEN 210 sections 1 and 2, respectively, believed that class participation virtually was ineffective or extremely ineffective for advancing theoretical knowledge for both male and female students. However, more than 50% of petroleum engineering students at the Qatar campus, agreed that taking classes online was effective or extremely effective. The size of the classes in synchronous learning may be the primary factor for the outcomes.

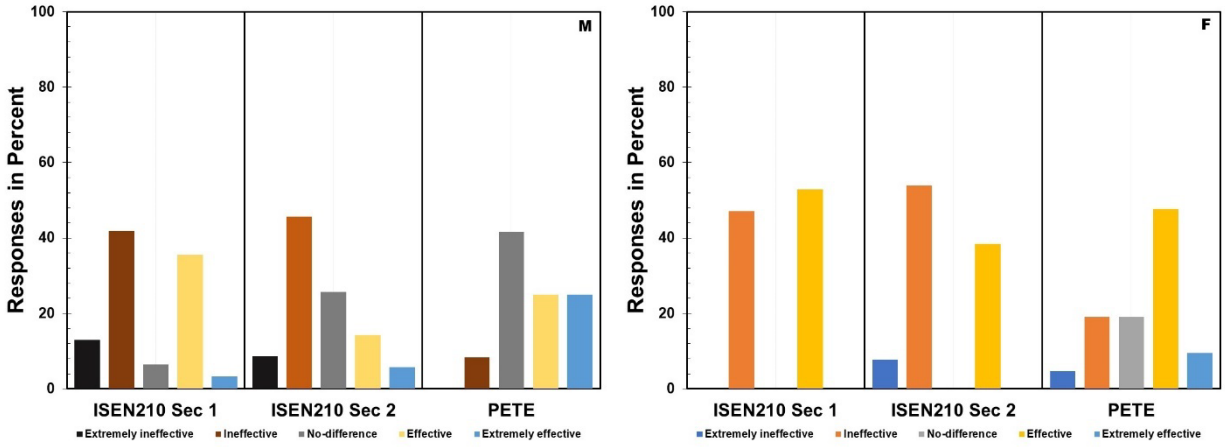

Figure 8. Participating in Class Remotely in Terms of Increasing Knowledge Theoretically

When students were asked to rate the efficiency of traditional face-to-face learning in terms of developing theoretical knowledge, the results are shown in Figure 9. Over 70% of respondents to the ISEN 210 sections 1 and 2, respectively, judged that conventional face-to-face learning was effective or extremely helpful for boosting theoretical knowledge for both male and female students. On the Qatar campus, petroleum engineering students reached the same conclusions. Students enrolled in ISEN 210 sections 1 and 2 and Qatar Campus choose conventional face-to-face learning over participating in class remotely (synchronous learning) to advance their theoretical knowledge.

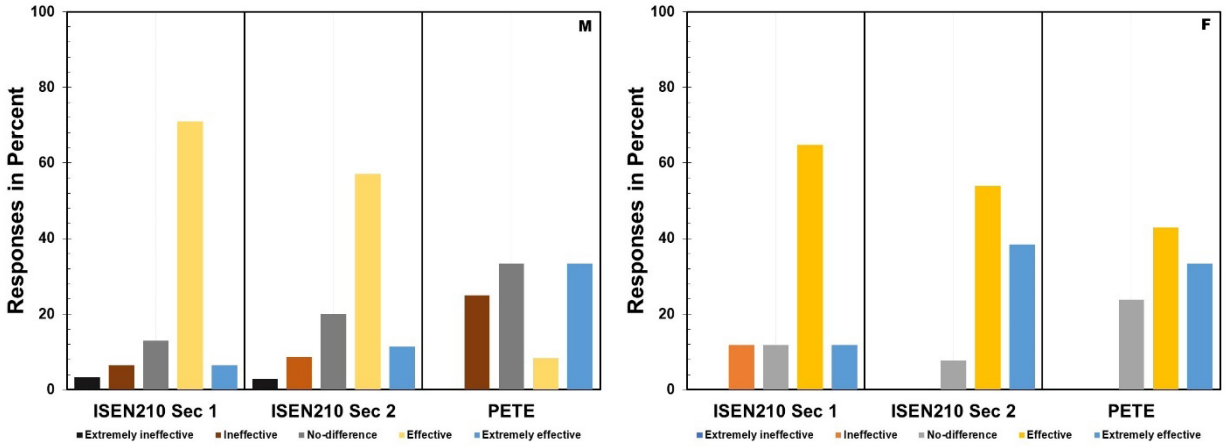

Figure 9. Participating in Traditional Face-to-face Learning in Terms of Increasing Knowledge Theoretically

The major issue during the pandemic was that engineering students were unable to conduct practical experiments in their technical labs. Any alternative method of delivering laboratory courses could not replicate the laboratory experience. Figure 10 shows the impact of remote participation in class in terms of raising engineering laboratory proficiency. On both campuses, the majority of engineering students had unproductive laboratory experiences. In ISEN 210 sections 1 and 2, more than 85% of students judged that participating in class remotely was ineffective or extremely ineffective for improving engineering laboratory skills for both male and female students. More than 67% of students in Qatar judged that participating in in-class activities remotely was useless or extremely ineffective for developing laboratory abilities.

To educate students, the universities had to innovate. They achieved this, among other things, by offering students a convenient and effective learning environment through virtual computer laboratories that closely resembled the actual computer labs they were no longer able to visit. Using virtual computer laboratories, students have access to all supported software in the university. Users of virtual labs just require PCs with the necessary capabilities and internet access in order to complete all of the experiments. Given the availability and proliferation of computers and other digital devices in universities, this is one of the benefits of virtual labs. The virtual computer lab is accessible through a web browser interface and is cross-platform. The centrally maintains all operating systems, servers, software, and applications, so end users are not required to install or maintain any of the programs or software on their own computers. All students need to do to access everything they would use in the physical campus computer lab is log in to the system.

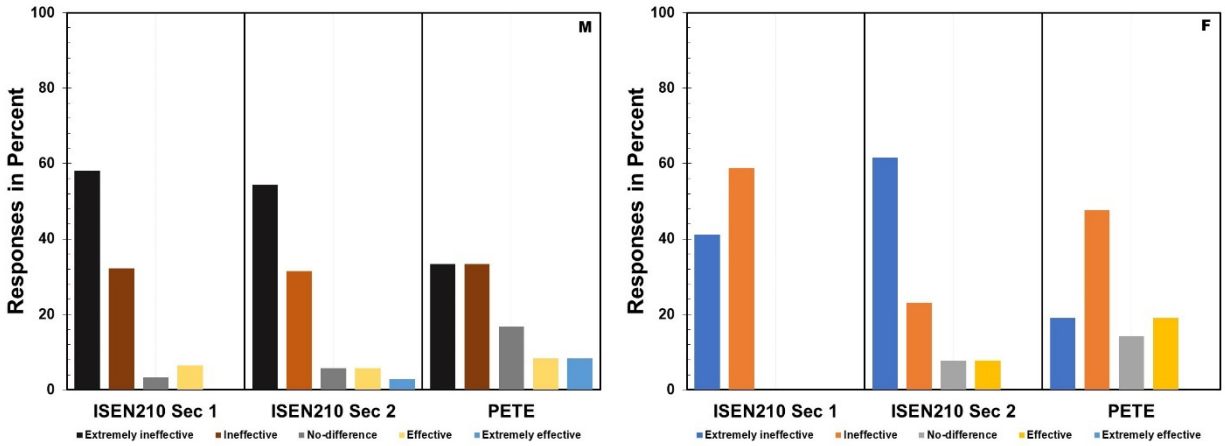

Figure 10. Participating in Class Remotely in Terms of Increasing Engineering Laboratories Skills

Figure 11 displays the rate of traditional face-to-face learning's effectiveness in raising engineering laboratories' ability levels. In ISEN 210 sections 1 and 2, more than 90% of respondents, respectively, believed that traditional face-to-face learning was excellent or extremely successful in enhancing engineering laboratory skills for both male and female students. More than 82% of students at the Qatar campus said that traditional face-to-face instruction was effective or very helpful in enhancing their ability to work in an engineering laboratory.

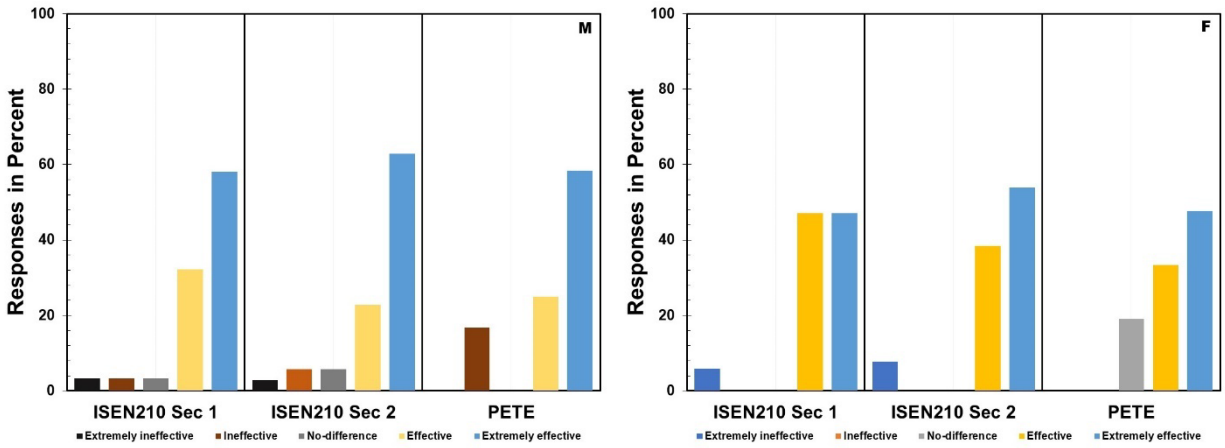

Figure 11. Participating in Traditional Face-to-face Learning in Terms of Increasing Engineering Laboratories Skills

In addition, students were not allowed to take part in laboratory activities for the undergraduate research program. Research activities might take place during the regular academic year or the summer and are intended to go beyond those connected with ordinary coursework. Under the guidance of a mentor, the undergraduate research program engages students, helps them develop their research abilities, and advances their professional development to strengthen Qatar's research infrastructure. The goal of the curriculum is "Learning by Doing." The UREP program not only promotes undergraduate development but also recognizes the important role that mentoring played in students' academic careers by our teachers. Undergraduate students had the chance to share the findings of their study with members of the industry at the Qatar Foundation Annual Research Conference (Retnanto et al. 2020). The exploration of the feasibility of nanoparticles in drilling fluids as an addition for fluid loss and wellbore stability is an example of a research subject shown in Figure 12.

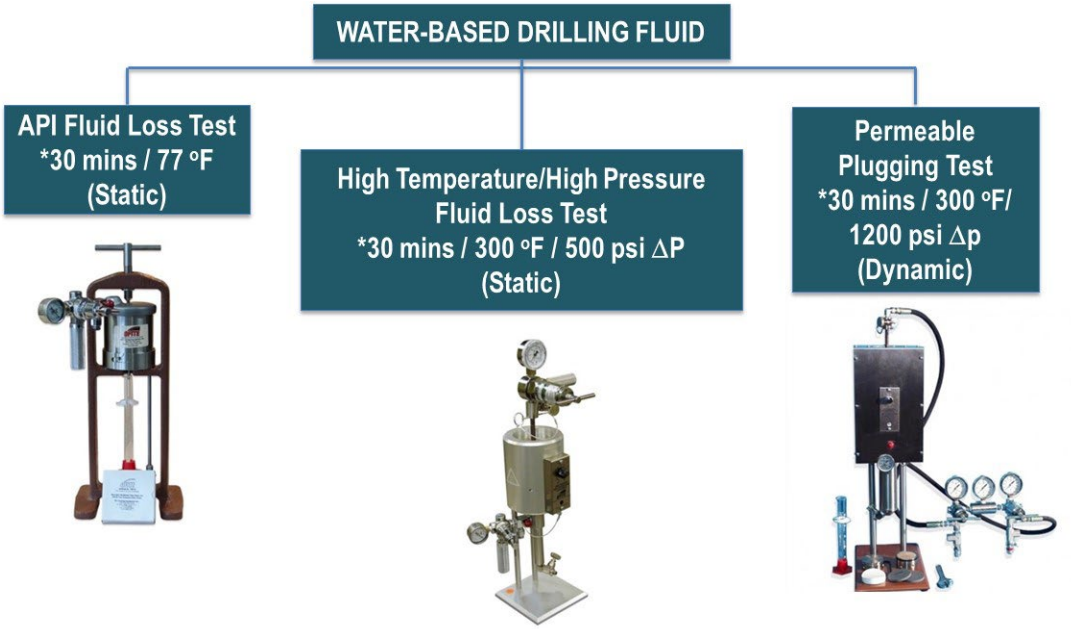

Figure 12. Experimental apparatus for investigation of the viability of Nanoparticles in drilling fluids as an additive for fluid loss and wellbore stability

6. Conclusion

There were some commonalities in the comments given by undergraduate students from the two institutions. The ability to use information technology (IT) effectively is essential for synchronous learning. High-speed internet accessibility had an impact on how students interacted with their peers and participated in class. However, because neither the academic institution nor the course instructors had any influence over the network's uploading or downloading speed, no questions about this issue were included in the questionnaire. It is also important to note that theoretical classes were favored to have access to course instructors and receive face-to-face training because these methods might hasten the learning process.

The survey results also revealed that students in classes that included laboratory components were less supportive of synchronous remote learning. The capacity to conduct practical experiments and conduct research is the primary drawback of remote learning for engineering students.

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Biographies

Dr. Albertus Retnanto is a Professor of Petroleum Engineering at Texas A&M University at Qatar and has been in the Petroleum Engineering program since 2009. He received his Ph.D. degree in Petroleum Engineering from Texas A&M University. He teaches undergraduate courses in well testing, petroleum production systems, production engineering, petroleum technical presentation, natural gas engineering, and integrated asset development and makes significant curriculum enhancements to several courses. He held a Principal position with Schlumberger and has more than 18 years of experience worldwide in technical and management positions in well testing, field development, and production enhancement. Dr. Retnanto is an active Program Evaluator (PEV) with the Engineering Accreditation Commission (EAC) of ABET.

Dr. Hamid R. Parsaei is an internationally recognized leader in the field of engineering education, manufacturing automation, economic and financial decision-making, leadership, and additive manufacturing, with more than three decades of experience in academia. He is a fellow of the Institute of Industrial and Systems Engineers (IISE), American Society for Engineering Education (ASEE), Society of Manufacturing Engineers (SME), and Industrial Engineering and Operations Management Society International (IEOM). Dr. Parsaei is an effective educator and an innovative researcher who draws on considerable expertise to lead colleagues toward visionary goals and exceptional results. He served as the Chair of the Department of Industrial Engineering at the University of Houston and Associate Dean of Academic Affairs at Texas A&M University at Qatar. He is a registered professional engineer in the State of Texas and an ABET Engineering Accreditation Commissioner and Program Evaluator. Dr. Parsaei is currently a Professor with the Wm Michael Barnes '64 Department of Industrial and Systems Engineering and Director of the College of Engineering Accreditation and Assessment.

Boback Parsaei is the Vice President of Operations and Chief Technical Officer with Integrated Technology Systems, Inc., an Engineering Consulting in Houston, Texas. Mr. Parsaei received his undergraduate degree and M.Eng. in Civil and Environmental Engineering from Texas Tech University and Texas A&M University, respectively. He is currently pursuing his Ph.D. degree in Civil and Environmental Engineering at Texas A&M University. He has extensive experience in the field of project management.