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Face-to-Face vs. Synchronous: An Observation in Undergraduate Engineering Classes on Students' Learning Experience

Albertus Retnanto, Ph.D.
Professor and Chair, Petroleum Engineering Program
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

Ameen Siddiqui
Graduate Student, Industrial and Systems Engineering
Texas A&M University
College Station, TX, USA
ameen.siddiqui@tamu.edu

Abstract

The introduction of distance education over several decades ago appropriately created and provided opportunities to those interested in pursuing education at their own pace. Distance education over time took several distinctions, including online learning, learning on-demand, etc. The high-speed internet and the introduction of interactive software significantly improved online learning. They attracted several educational and academic institutions around the world to utilize these mediums to deliver educational and learning materials on demand. These delivery methods have proven to be cost-effective and significantly attractive to academic and technical institutions interested in expanding their markets and allowing applicants from a distance to pursue education and improve their technical skills. With the arrival of the COVID-19 pandemic, online education using digital interactive software became a norm and many education institutions encouraged their instructional teams to learn and adopt an institution-recommended system medium to deliver their lectures from the traditional face-to-face or in-person to synchronous or asynchronous methods. Texas A&M University campuses, including College Station and the campus located in Qatar (Middle East), followed the recommended delivery method in March 2020. Texas A&M University formally started delivering in-person degree programs in its Qatar campus in the fall of 2002. This campus is located in Hamed Bin Khalifa Campus (formerly known as Education City). Since its inception, it has been offering four ABET-accredited engineering degree programs in chemical, electrical, mechanical, and petroleum engineering. By May 2023, over 1,300 completed and received undergraduate degrees in these four disciplines. The campus has historically and consistently been well regarded for its quality education and innovative approaches to teaching and learning methods in the Middle East and North Africa (MENA Region). An empirical study has been 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 article

is intended to the results of this study and also report on the observations of students' participation and academic performance during remote in-class (synchronous) and face-to-face learning.

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

1. Introduction
Capacity building and developing a strategic plan to move from the traditional agricultural or fossil-based economy to digital technology has been studied and, in many cases, have been undertaken since early 1990s by many countries around the globe. The existing wealth and natural resources in several countries in the Middle East afforded them to initiate such long-term plans. Several nations in the Middle East named these initiatives as Vision 2030 by which they stipulated their economy will be less depending on the oil and its derivatives and more digital and high technology-based opportunities for their youth and the new generation of workforce. By investing and adopting Western education, many countries particularly around Persian Gulf invited and welcomed American and European based academic institutions to open branches in the Middle East and offer identical degree programs in the region (Retnanto et al., 2023; Retnanto et al., 2022; Retnanto et al., 2021; Retnanto et al., 2020).

Due to existing local interest, many degree programs both at graduate and undergraduate levels in engineering, law, journalism, political science, medicine, business and finance, interior design have been attractive since their introduction in early 2000s. Many countries in the Middle East, in particular, surrounding Persian such as Qatar, United Arab Emirates, Kuwait, Bahrain, have actively embarrassed the arrival of these opportunities and invested heavily mimicking US and European style training facilities and have actively encouraged their high school graduate to join these programs.

Qatar, geographically a peninsula surrounded by Persian Gulf waters in the east, north, and west and connected by land in the south to the Kingdom of Saudi Arabia, has been one of the early adopters of Western Style education and built an impressive facility currently known as Hamed Bin-Khalifa University (formerly recognized as Education City). Qatar made significant investment in building world class infrastructure including roads, hospitals, ground transpiration, communication networks, and many others in addition to education. Although the country's formal and official language is Arabic, a large percentage of population are fluent in English and this attracted many engineers, skilled medical and healthcare professionals, and technical craftsmen, to look for employment there. Qatar massive investment in infrastructure projects including, urban planning and residential and commercial constructions, broadcasting and communications, roads, stadiums, education including K-12, has made Qatar a new icon in the Persian Gulf. A higher standard in performance combined with durability and reliability established by the various sectors of government, significantly contributed to the advancement of education, healthcare, and public services.

Qatar Foundation, a government led, non-profit organization upon its formation in late 1990s took the initiative to serve as the lead entity to modernize education by inviting several top tier American and European academic institutions to open campuses in capital of Qatar, Doha. Virginia Commonwealth University was the first American school to open a branch campus in 1998 and subsequently, Weill Cornnell Medicine (2002), Texas A&M University (2003), Carnegie Mellon University (2004), Georgetown University (2005), Northwestern University (2008) opened their campuses under the financial support of Qatar Foundation. These branch campuses are all located in Education City (recently been renamed as Hamed Bin Khalifa University-HBKU campus), a very modern location of the Qatar capital city of Doha. Texas A&M University at Qatar has awarded over 1,300 degrees to its graduates in the Chemical Engineering, Electrical Engineering., Mechanical Engineering, and Petroleum Engineering since its inception in 2002.

2. Background
In the Spring of 2020, and the arrival of COVID epidemy which resulted in significnat reducation in the productivity and services normally offered by the public and and priate sectors, envouraged the entities to find safe alternative and economical and affordable options to continue offering their services. In the United States, local and federal gvoerment offices tried to further relied on internet to deliver their services while maintaining simialr quality to some degrees. Practically all academic institutions started traning their empyees on the use of available mass communication systems such Zoom, SKYPE, and other tools as a mean to reaching out to their studnets. Although, higher internet speed such as 5G was relatively a new phonamouna in the Unied States and Western countries, Qatar has been utilizing a well tested fiber optics 5G speed communication systems since 2018. Due to prioir experince of Qatar campus studnets in

taking some eletive remotely offered courses switching to this delivery method became a preferred choice with a minimim to no required training times.

Both Texas A&M University main campus in College Station and its Qatar campus adopting syncronous distance education option as a viable delivery method at the absence of face to face due to pendemic.

3. Methods and Data Collection

The study contrasts online in-class training with conventional in-person teaching and learning techniques. Because of this, the authors provided a quick survey asking students about their experiences enrolling in in-person and online programs. The survey was reviewed and authorized by the Human Research Protection Program at Texas A&M University's College Station campus. The questionnaire consisted of twenty questions covering basic demographics, advantages and disadvantages of in-person versus online education, and remote access to course materials (Retnanto et al., 2022). The study's participants were petroleum engineering majors. ISEN 210: Introduction to Industrial and Systems Engineering Design was the only undergraduate course offered on the Texas A&M University campus in College Station. Undergraduate petroleum students conducted the two sections of ISEN 210 that took part in this study during the same spring semester of 2021. (Retnanto, 2022).

Students were given a quick survey asking about their experiences signing up for in-person and virtual classes. The questionnaire consisted of twenty questions covering the essentials. Table 1 contains a list of students who participated in the survey. This report presents the results of an empirical inquiry that was completed by 129 students (Table 1-. Table 2).

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

The distribution of student levels from sophomore to senior is seen in Table 2. Throughout the academic semester, ISEN 210 is available in several parts.

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

Thirteen of the 48 students who took part in section one of the ISEN 210 were female, and thirty-one were male. Thirteen female and thirty-five male students made up section two of the ISEN 210. There were twelve males and twenty-one ladies among the undergraduate petroleum students. Ten sophomores, thirty-five juniors, and three seniors were enrolled in ISEN 210, section 1, whereas twenty-two sophomores, twenty-five juniors, and one senior student were registered in ISEN 210, section 2. Thirteen sophomores, seven juniors, and thirteen seniors were among the undergraduate petroleum students. About 42% of the undergraduate petroleum students at the Qatar campus selected "high" for their IT skills, despite the fact that more than two-thirds of the students enrolled in ISEN 210 parts 1 and 2 indicated that they had moderate IT skills (Figure 1). Prior to the pandemic, almost half of the students enrolled in ISEN 210 sections 1 and 2 had engaged in any kind of synchronous learning. By contrast, almost 70% of the undergraduate petroleum students on the Qatar campus never engaged in any kind of remote learning.

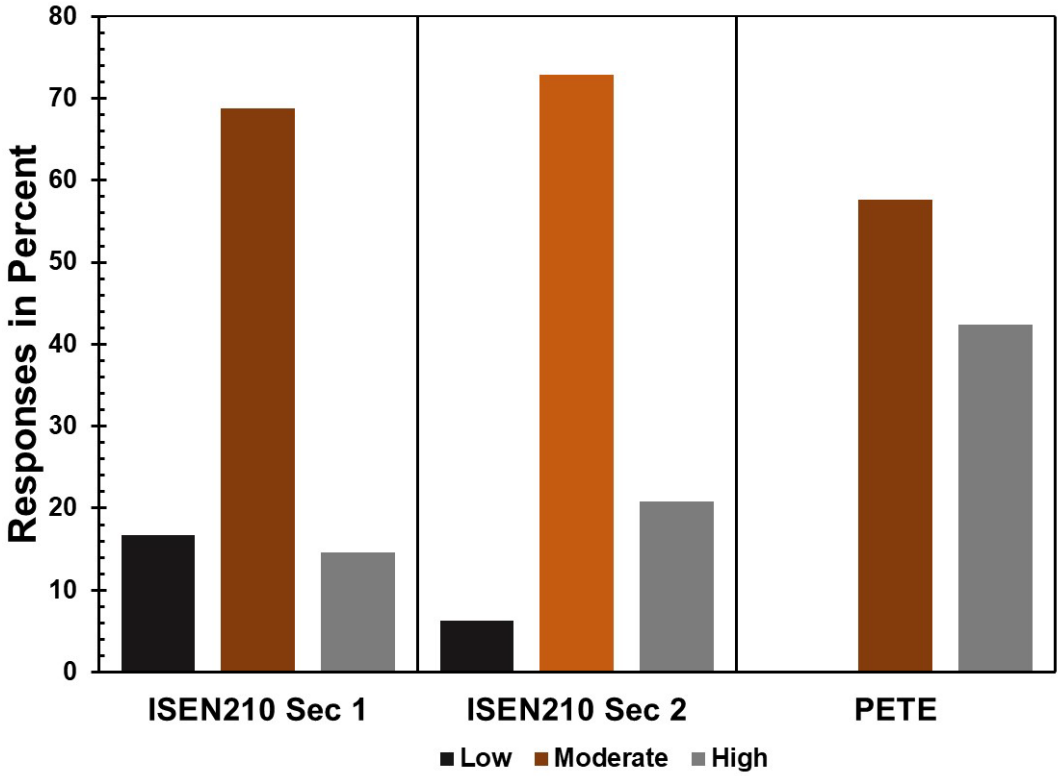

Figure 1. Students Level Information Technology (IT) Skills

The benefits of distant participation in class (synchronous learning) are illustrated in Figure 2. Access to online materials was deemed by a vast majority of students enrolled in ISEN 210 parts 1 and 2 to be one of the most important benefits of participating in the class remotely (80% in section 1 and 70% in section 2). "The ability to stay home" was cited as a major benefit of taking the class remotely by 80% of students enrolled in ISEN 210, sections 1 and 2, respectively. Students enrolling in the undergraduate petroleum program on the Qatar campus gave similar answers. The "ability to stay at home" was evaluated by the Qatar campus students at 85%, and 76% of them chose "access to online materials" as one of the major benefits of synchronous learning. Overall, students regarded the class interaction as the least beneficial aspect of synchronous learning (24% for Qatar Campus students and 8% for ISEN 210 students in sections 1 and 2).

The drawbacks of distant participation in class (synchronous learning) are shown in Figure 3. Approximately 83% of students enrolled in ISEN 210, sections 1 and 2, identified the "reduced interaction with the teacher" as the most significant drawback of synchronous learning, while 88% of undergraduate petroleum students identified the "technical problems" as the main drawback of synchronous learning.

Figure 4 illustrates the logistical difficulties associated with participation in a remote class. For the ISEN 210, sections 1 and 2, as well as the TAMUQ students, quiet/private study spaces and dependable internet or remote connections rank among the highest. Students taking ISEN 210, parts 1 and 2, said that the largest logistical issue was finding a dependable internet source or distant connection, with over 60% of students citing this as the case. Fifty percent of the students in the petroleum engineering program had similar answers.

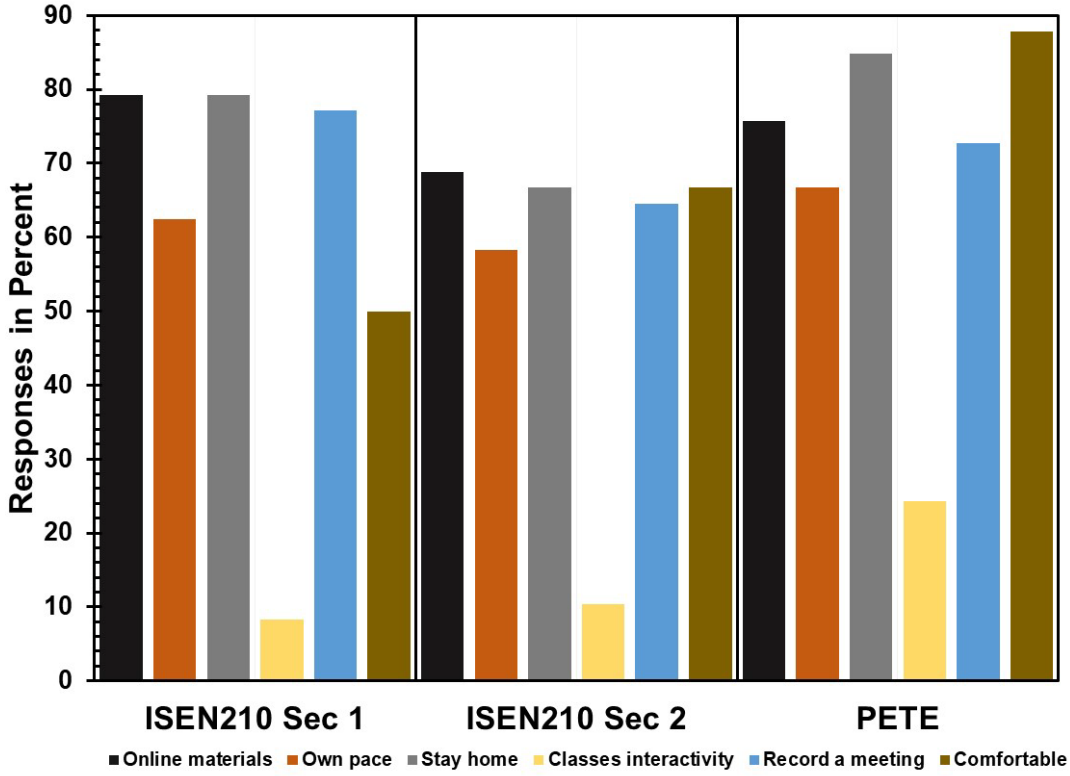

Figure 2. Advantages of Participating in Class Remotely (synchronous learning)

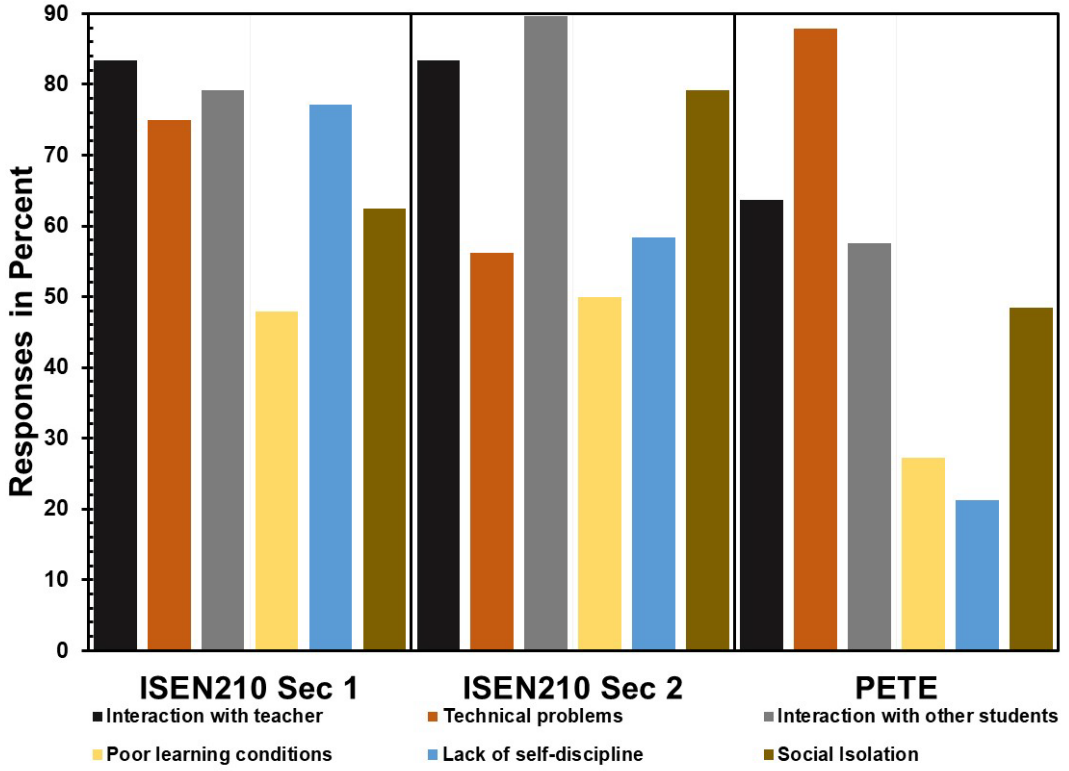

Figure 3. Disadvantages of Participating in Class Remotely (synchronous learning)

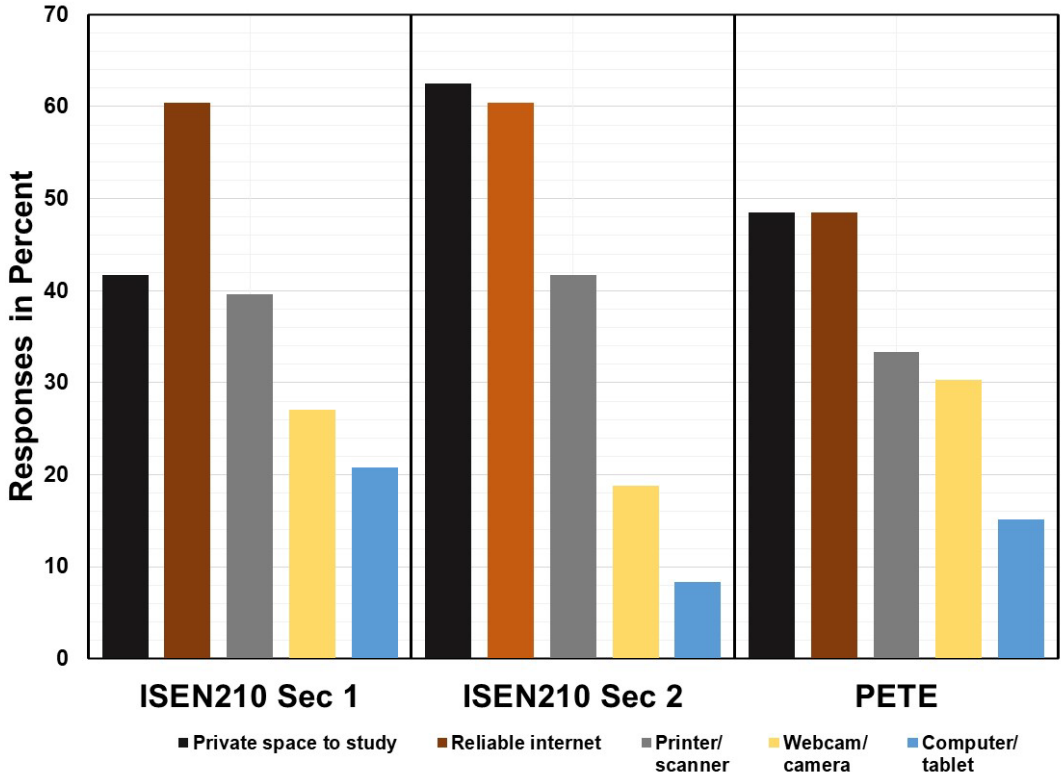

Figure 4. Logistical Challenges of Participating in Class Remotely

4. Comparative Study of Synchronous vs. Face-to-face Instructions

Students were asked to judge the success of participating in class remotely (synchronous learning) in terms of theoretical knowledge expansion. The findings are shown in Figure 5. According to the results of ISEN 210 sections 1 and 2, more than 52% and 56%, respectively, thought that taking classes remotely was either extremely ineffective or ineffective in terms of theoretical knowledge acquisition. Just 18% of petroleum engineering students on the Qatar campus, however, felt that attending classes virtually was either useless or very ineffective. The size of the class in synchronous learning may be the primary cause.

When students were asked to rate how effective traditional face-to-face learning was at increasing their theoretical knowledge, the results of the survey are displayed in Figure 6. In the ISEN 210 parts 1 and 2, more than 77% and 75% of respondents, respectively, thought that taking part in conventional face-to-face instruction was extremely effective or effective in gaining theoretical knowledge. On the Qatar campus, over 64 percent of students studying petroleum engineering reached the same conclusions. Students enrolled in ISEN 210 parts 1 and 2 and Qatar Campus prefer traditional face-to-face learning over participating in class remotely (synchronous learning) in order to gain theoretical information.

The results of a survey asking students to judge how effective remote learning was in helping them develop their practical and calculation skills are shown in Figure 7. In the ISEN 210 parts 1 and 2, more than 54% and 44%, respectively, said that taking classes remotely was ineffective or very ineffective for improving practical/calculation skills. In a similar vein, 39% of students majoring in petroleum engineering on the Qatar campus felt that taking classes remotely was either ineffective or very ineffective.

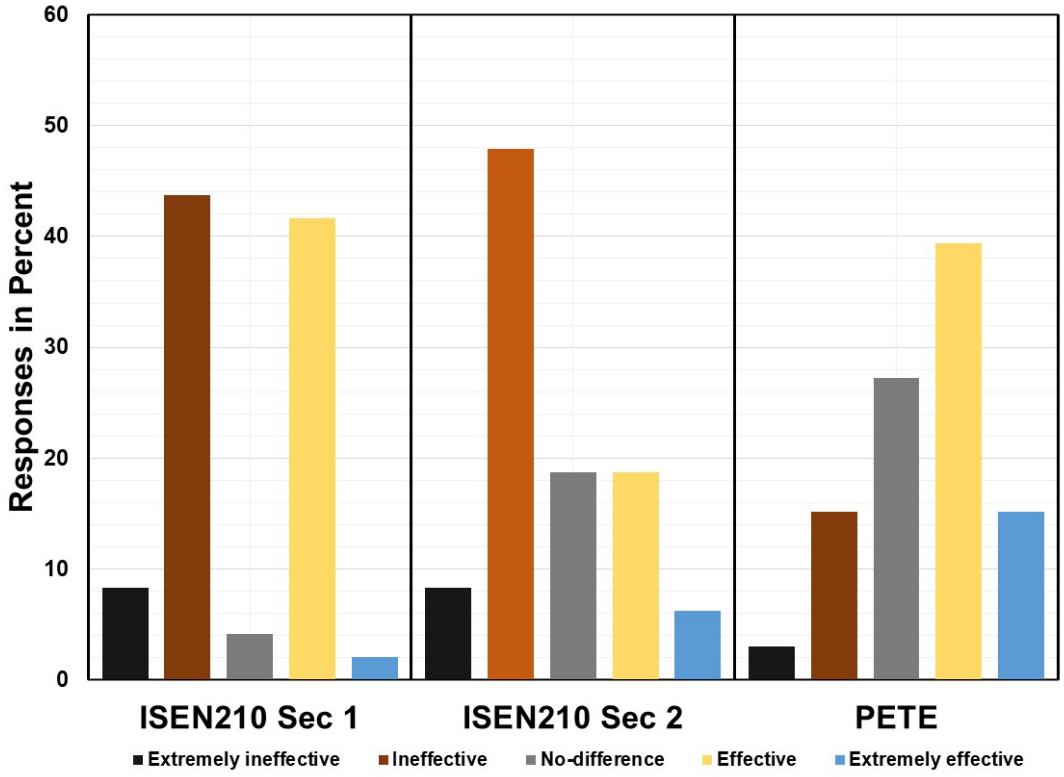

Figure 5. Participating in Class Remotely in Terms of Increasing Knowledge Theoretically

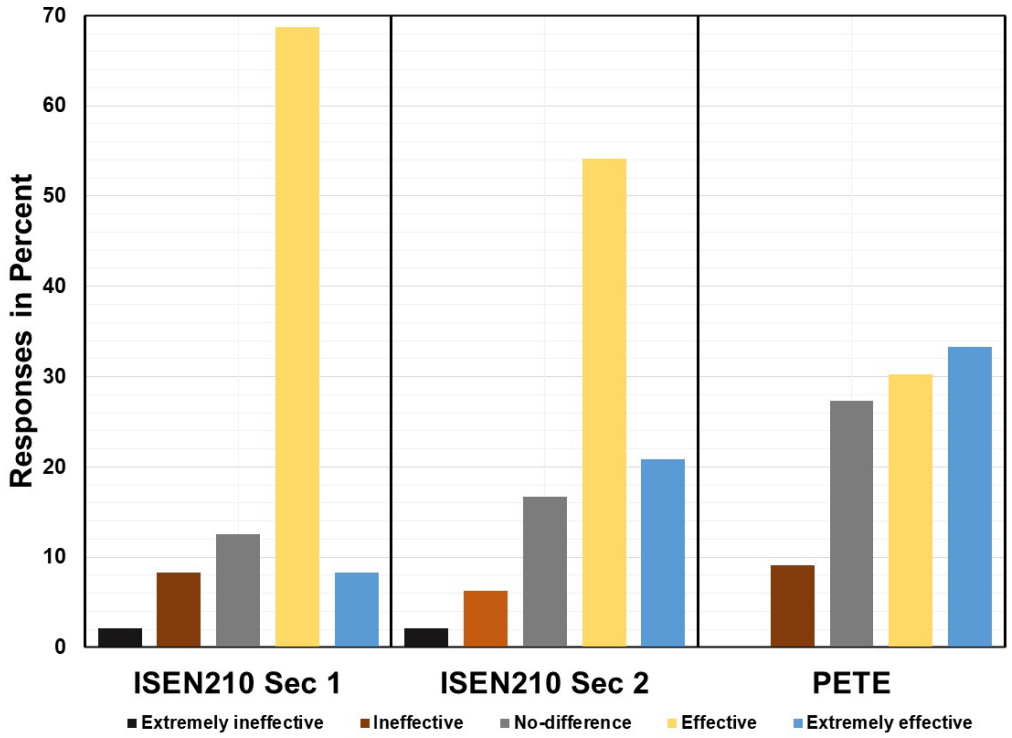

Figure 6. Participating in Traditional Face-to-face Learning in Terms of Increasing Knowledge Theoretically

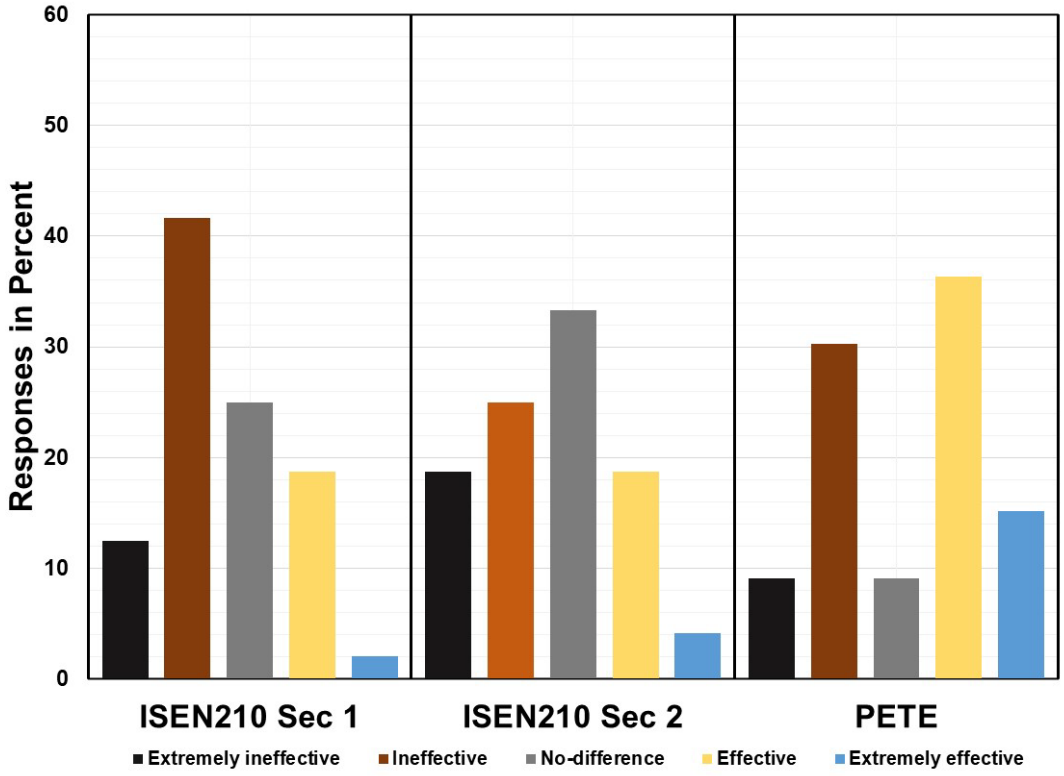

Figure 7. Participating in Class Remotely in Terms of Increasing Practical/Calculation Skills

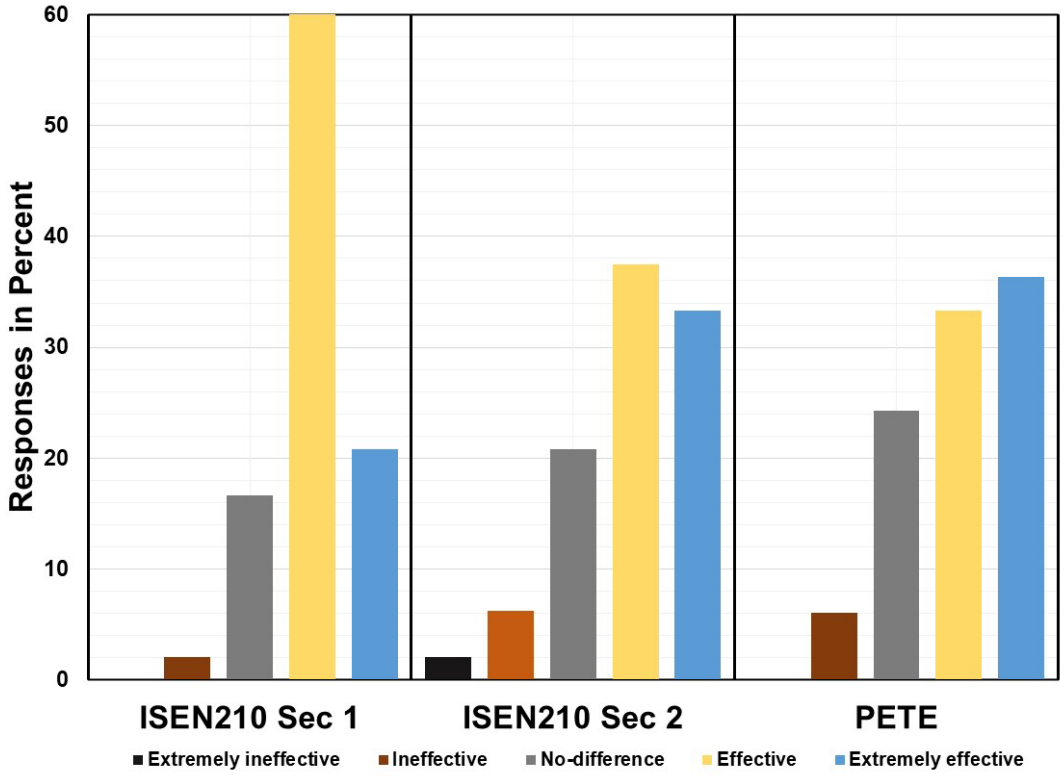

Figure 8. Participating in Traditional Face-to-face Learning in Terms of Increasing Practical/Calc. Skills

The survey results that were obtained when students were asked to evaluate how well traditional face-to-face instruction increased their practical and calculation skills are shown in Figure 8. Regarding improving practical/calculation abilities through conventional face-to-face learning, over 81% and 71%, respectively, of respondents in ISEN 210 sections 1 and 2 said it was either extremely successful or effective. On the Qatar campus, over 70% of students studying petroleum engineering reached the same conclusions. Students enrolled in ISEN 210 parts 1 and 2 and Qatar Campus choose conventional face-to-face learning over participating in class remotely (synchronous learning) in order to improve their practical/calculation skills.

The largest obstacle during the pandemic was that engineering students were unable to conduct practical experiments in their technical labs. The laboratory experience cannot be replicated through any other method of delivering the courses. Figure 9 shows the rate of efficacy of remote participation in class in terms of improving abilities in engineering laboratories. For the most part, engineering students on both schools had unproductive laboratory experiences. In the ISEN 210 parts 1 and 2, more than 94% and 85% of respondents, respectively, said that taking classes remotely was either extremely ineffective or ineffective in improving students' engineering laboratory skills. Over 67% of students on the Qatar campus said that taking laboratory skills classes virtually was either inefficient or very ineffective.

Conversely, Figure 10 shows the rate of effectiveness of traditional face-to-face learning in terms of improving the abilities of engineering laboratories. Engineering students believed that the laboratory courses ought to be taught as conventional in-person instruction on both campuses. Regarding the effectiveness or extremely effectiveness of traditional face-to-face learning in enhancing engineering laboratory abilities, more than 92% and 88%, respectively, responded in the ISEN 210 sections 1 and 2. More than 82% of students on the Qatar campus said that improving engineering laboratory skills through traditional face-to-face instruction was very or extremely beneficial.

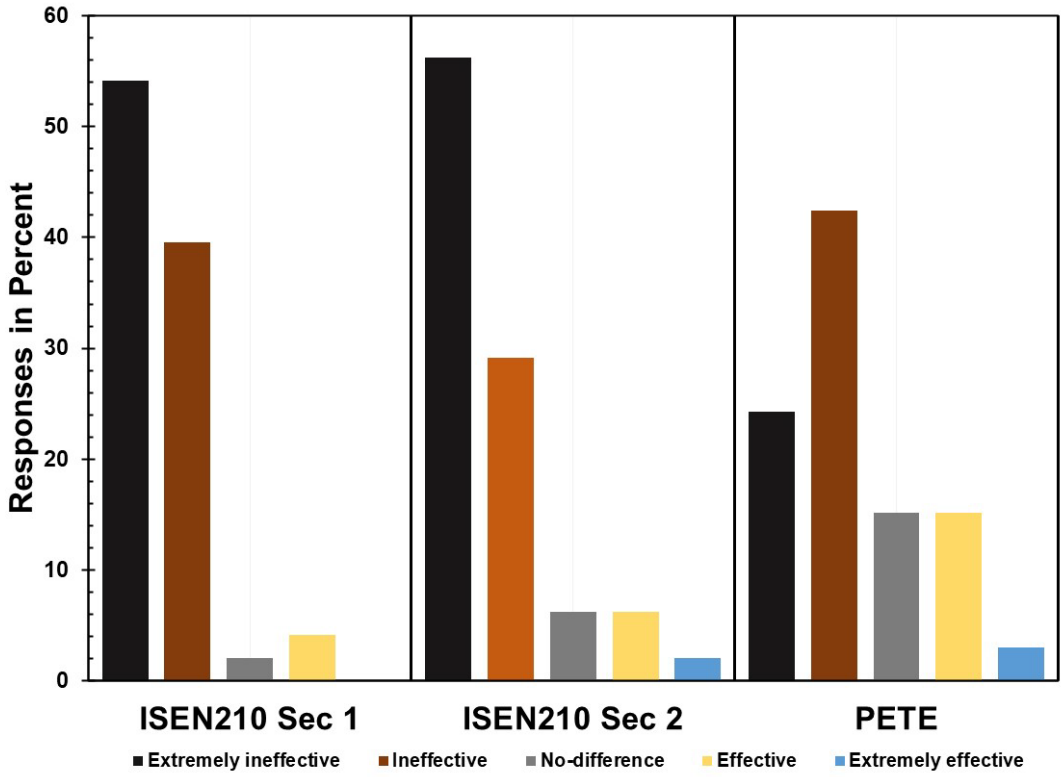

Figure 9. Participating in Class Remotely in Terms of Increasing Engineering Laboratories Skills

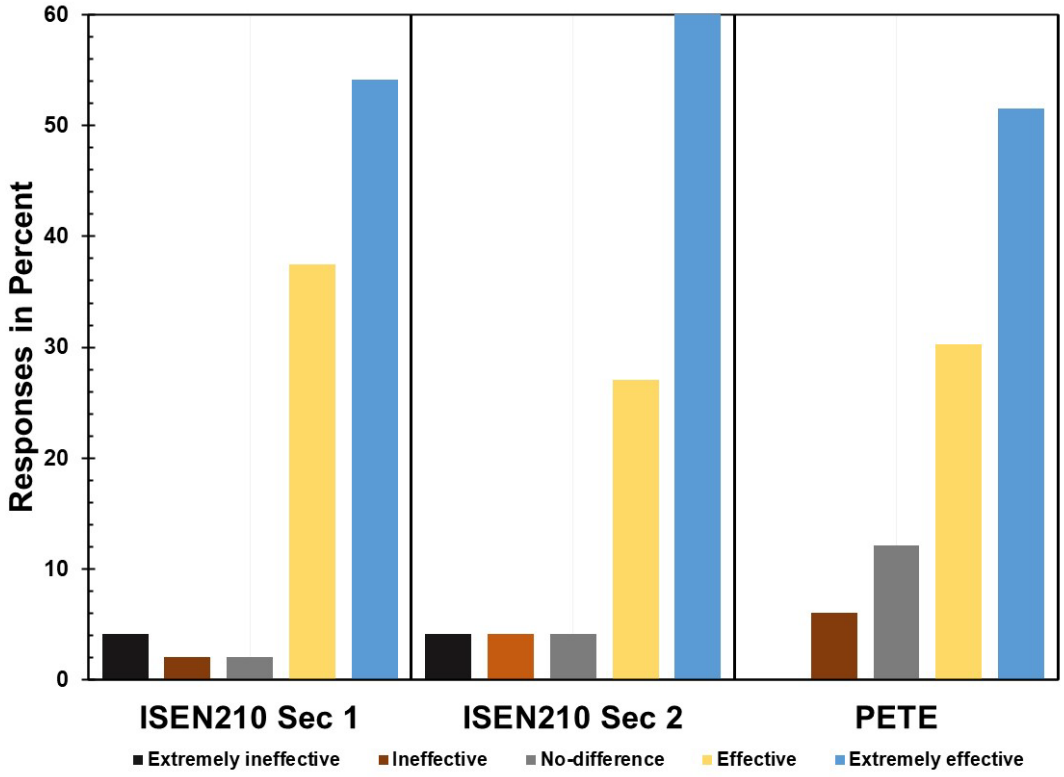

Figure 10. Participating in Traditional Face-to-face Learning in Terms of Increasing Eng. Lab. Skills

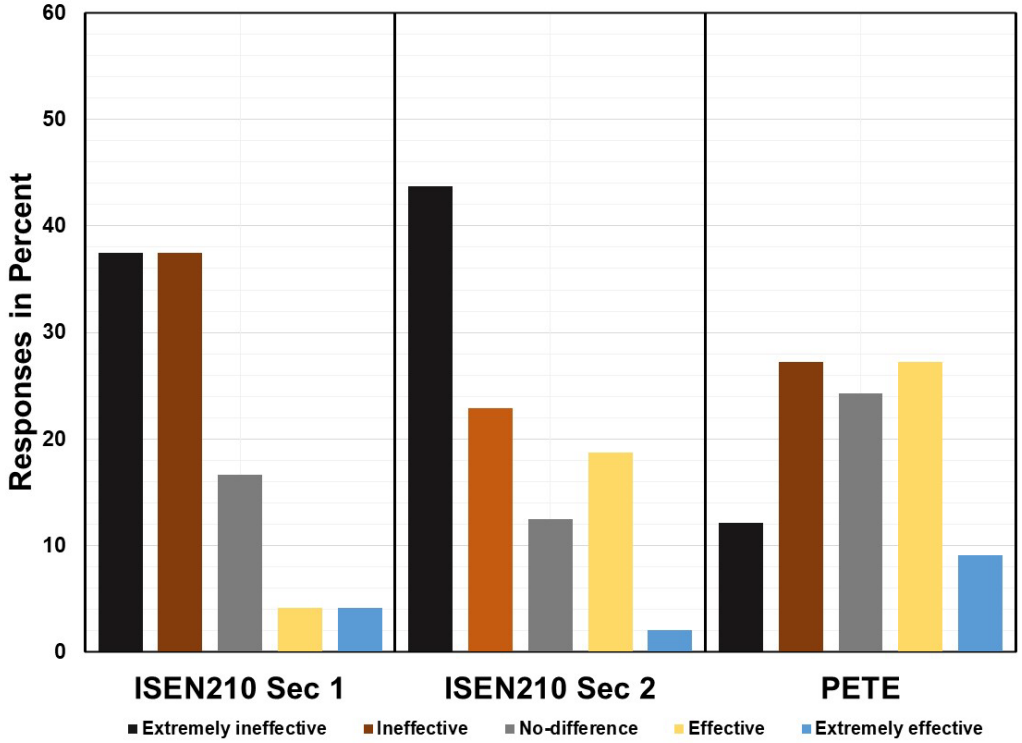

Figure 11. Effectiveness of Participating in Class Remotely in Terms of Increasing Communication Skills

One important finding from the study was that students were asked how beneficial it was for them to participate in class virtually in terms of improving their communication skills (Figure 11). In the ISEN 210 parts 1 and 2, more than 75% and 67% of respondents, respectively, said that taking classes remotely was either extremely ineffective or ineffective in terms of improving communication skills. Only 40% of the students studying petroleum engineering on the Qatar campus reached the same findings, though. Additionally, 36% of Qatari undergraduate students studying petroleum concluded that in-class (synchronous) remote instruction was effective or extremely effective, compared to less than 20% (8% in section 1 and 20% in section 2) of students enrolled in the ISEN 210 course who found the instruction to be effective or extremely effective.

In contrast, students believe that traditional face-to-face classroom participation is more successful in helping them develop their communication abilities (Figure 12). Just 8% of respondents to ISEN 210 parts 1 and 2 thought that doing traditional face-to-face classes was ineffective or very ineffective for improving communication skills. 6% of the petroleum engineering students on the Qatar campus reached a similar conclusion. Additionally, while 60% of Qatari undergraduate students studying petroleum concluded that traditional face-to-face instruction was effective or extremely effective, over 80% of students enrolled in the ISEN 210 (83% in section 1 and 81% in section 2) obtained a similar observation.

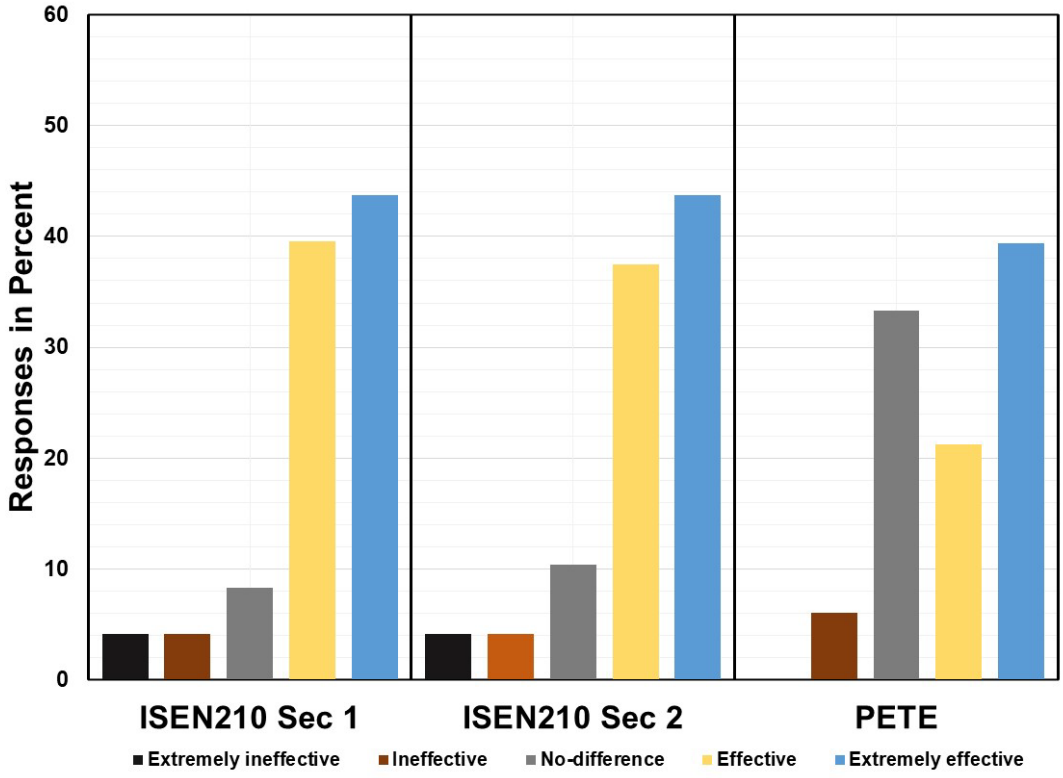

Figure 12. Effectiveness of Traditional Face-to-Face Learning in Terms of Increasing Communication Skills

Students' involvement in class is crucial to their learning process. Figures 13 and 14 depict student involvement in both traditional face-to-face instruction and remote in-class instruction (synchronous learning). One of the survey's key findings was that students in the larger class felt very ineffectual or that their distant involvement in class was ineffective. As can be seen in Figure 13, over half of the participants in ISEN 210 parts 1 and 2 (58% in section 1 and 56% in section 2) felt that their involvement in class was extremely poor or ineffective. Regarding the reduced class sizes at the Qatar location, almost 45% of them thought that remote participation in class was either extremely successful or effective. A variety of delivery methods for the course and after-hours help were offered by the faculty. On the other hand, fewer than 25% of students in ISEN 210 sections 1 and 2 reached that conclusion.

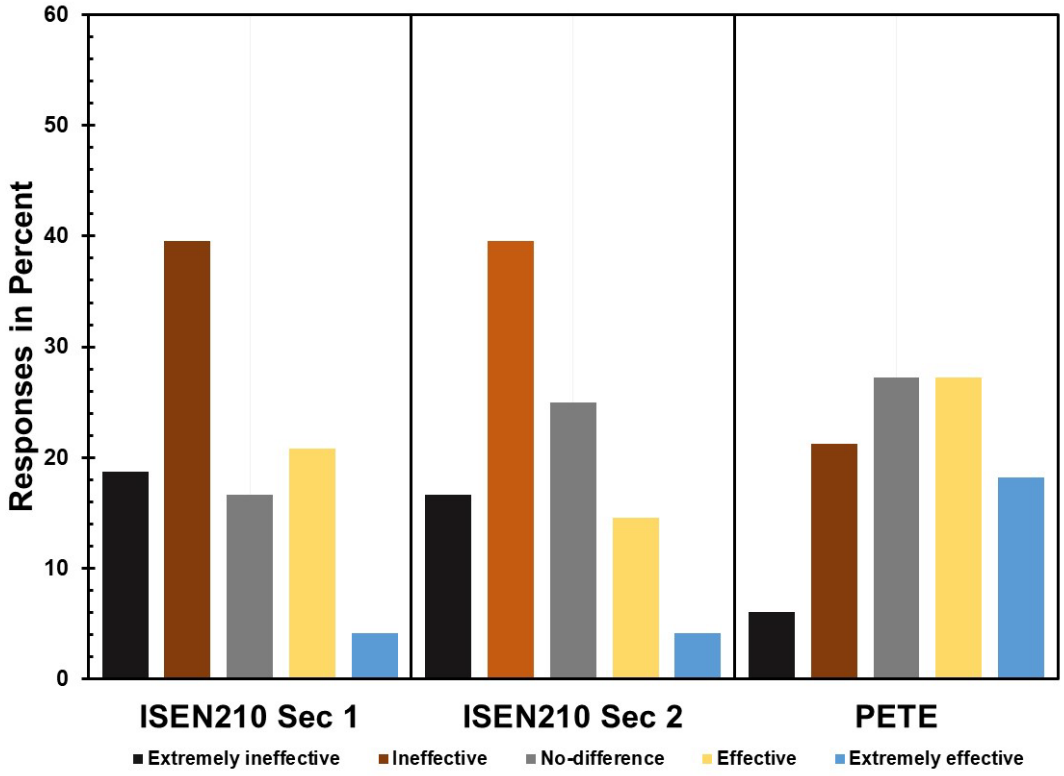

Figure 13. Class participation during in-class remotely (synchronous learning)

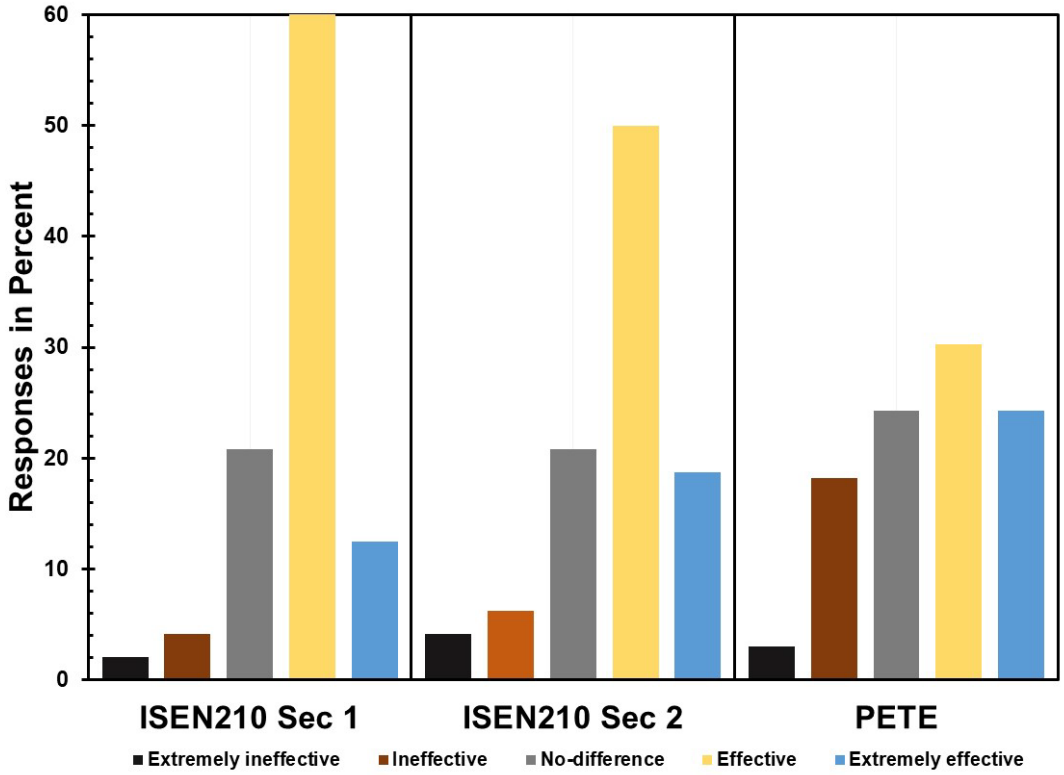

Figure 14. Class participation during traditional face-to-face learning

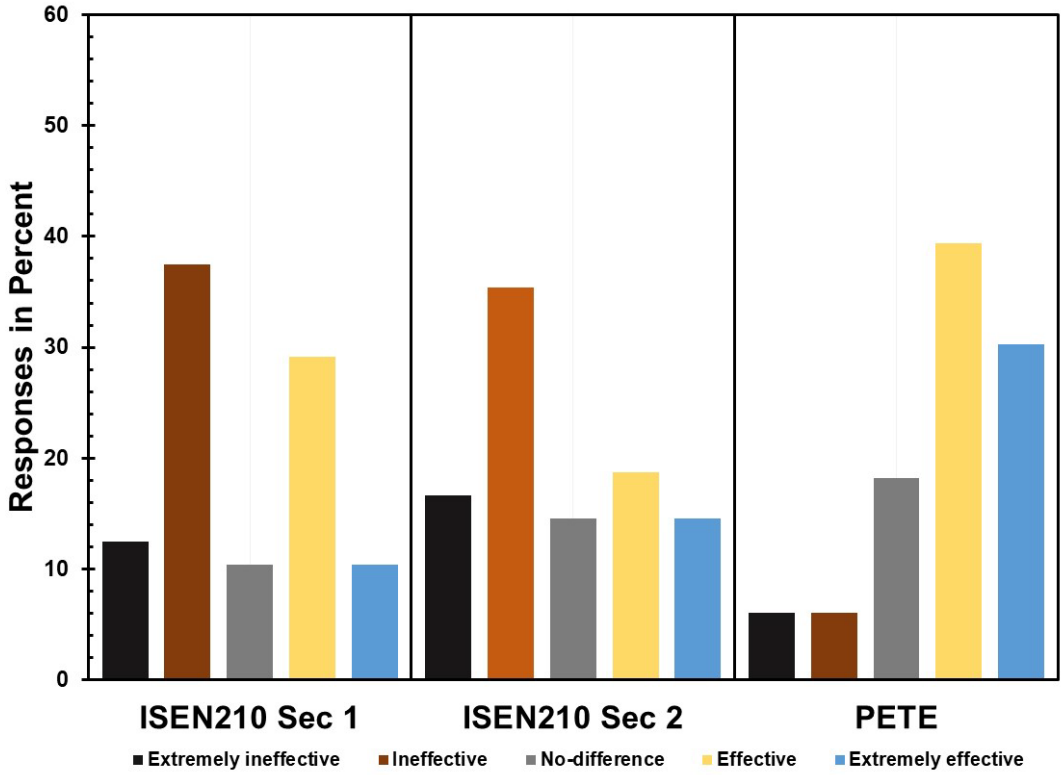

Figure 15. Academic performance during in-class remotely (synchronous learning)

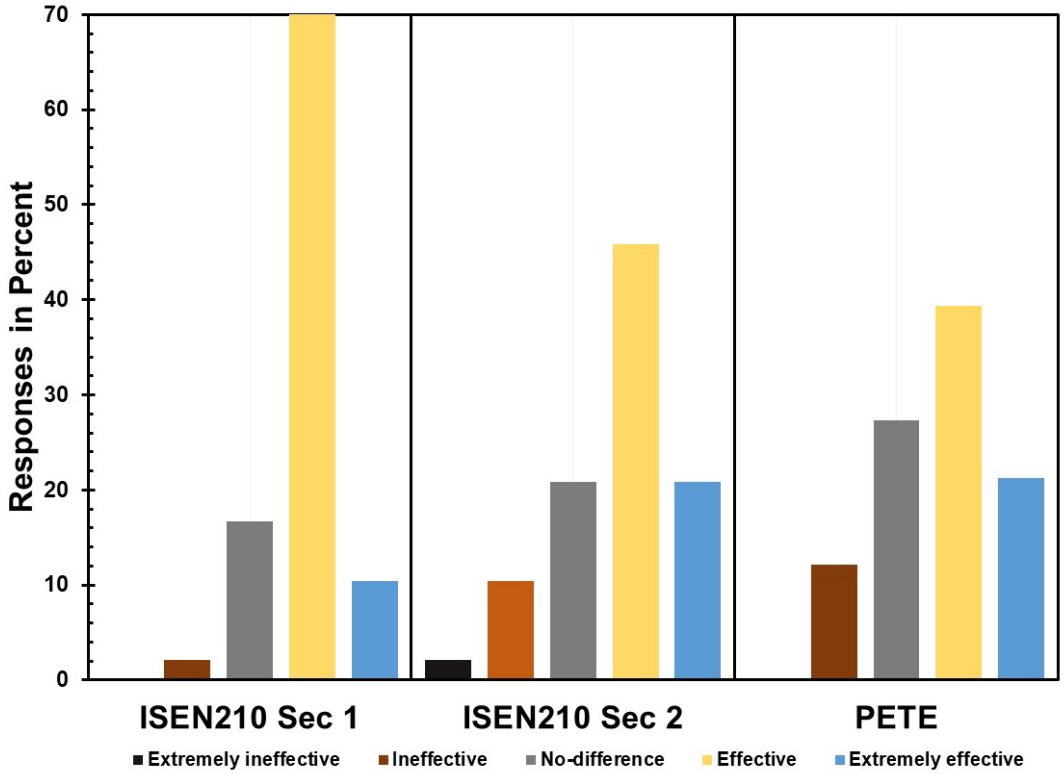

Figure 16. Academic performance during traditional face-to-face learning

The academic achievement during traditional face-to-face learning and remote in-class learning is displayed in Figures 14, 15 and 16. More than half of the participants in ISEN 210 sections 1 and 2 reported that their academic performance was ineffective or very ineffective. In contrast, more than 81% and 66%, respectively, of respondents in ISEN 210 sections 1 and 2 said that their academic performance was either effective or extremely effective. Just about 12% of students on the Qatar campus said their academic achievement was incredibly ineffective or ineffective. Additionally, almost 60% of respondents said that both cases' academic achievement was effective or extremely effective.

There appears to be a direct correlation between undergraduate students' academic achievement and their involvement in class. Participation in class is evidently essential to improving their learning process.

5. Conclusion

Undergraduate students from both universities' responses revealed a number of commonalities. The results of the survey showed that students' academic achievement was impacted by their engagement in class. It's also important to note that having in-person training and availability to course instructors were chosen because they both have the potential to accelerate learning.

The survey's findings also revealed that, in comparison to synchronous remote learning, fewer students attended classes that included laboratory components. The primary drawback of remote learning for engineering students is the inability to conduct research and carry out practical experimentation. Academic achievement seems to be higher in the traditional face-to-face setting.

References

Amani, S. and Parsaei, H. R., Online Education: Training Future Talent remotely, *Proceedings of the 1st Industrial Engineering and Operations Management Global Engineering Education Virtual Conference*, November 15-16, 2020.

Commins, D., The Gulf States: A Modern History, *I. B. Tauris*. p. 16. ISBN: 978-1848852785, 2012.

Magee, P., The Archaeology of Prehistoric Arabia, *Cambridge Press*. pp. 50, 178. ISBN: 9780521862318 ,2014. Qatar National Development Strategy 2011-2016, Doha, *Qatar: Gulf Publishing and Printing Company*, April 2015.

Retnanto, A., Alyafei, N., Fadlelmula, M., and Sheharyar, A. The Impact of Practical Experiences on the Development of Petroleum Engineering Education. *Proceeding SPE Annual Technical Conference and Exhibition, Society of Petroleum Engineers*, Virtual, 26-29 October 2020.

Retnanto, A., Parsaei, H. R., and Parsaei, B., Teaching and Learning Using In-Class Remotely vs. Traditional Face-to-Face Methods: An Empirical Study, *Proceedings of the International Conference on Industrial Engineering and perations Management*, Manila, Philippines, March 7-9, 2023.

Retnanto, A., Parsaei, H. R. and Parsaei, B., A Survey to Understand Students' Preference between Synchronous and Face-to-Face Instructional Methods in an Undergraduate Engineering Class in the United States and an Overseas Campus, *Proceedings of the International Conference on Industrial Engineering and Operations Management*, Istanbul, Turkey, March 7-10, 2022.

Retnanto, A., Parsaei, H. R. and Parsaei, B., Building Communication Strengths and Skills for Non-native English-Speaking Engineering Students, *Proceedings of the International Conference on Industrial Engineering and Operations Management*, Dubai, United Arab Emirates, March 10-12, 2020.

Retnanto, A., Parsaei, H. R. and Parsaei, B., Educating Next Generation of Engineers, *Proceedings of the 1st Industrial Engineering and Operations Management Global Engineering Education Virtual Conference*, November 15-16, 2020.

Retnanto, A., Parsaei, H. R. and Parsaei, B., Preparing New Engineers for the Job Skills Demanded in the 21st Century, *Proceedings of the 2nd Asia Pacific International Conference on Industrial Engineering and Operations Management*, Surakarta, Indonesia, September 14-16, 2021.

Toth, Anthony, Qatar: Historical Background, A Country Study: Qatar (Helen Chapin Metz, editor), *Library of Congress Federal Research Division*, January 1993.

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. 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.

Ameen Siddiqui is currently pursuing a Ph.D. degree in the Wm Michael Barnes ’64 Department of Industrial and Systems Engineering at Texas A&M University. Mr. Siddiqui holds an undergraduate degree in Mechanical Engineering from UP Technical University, India in 2016. He also received two Master of Science degrees in Chemical Engineering and Industrial and Systems Engineering, from Texas A&M University, in 2020 and 2023, respectively. His research interests are in multi-attribute decision-making, automation, artificial intelligence in decision-making, and engineering education. Mr. Siddiqui is active in student chapters of the Institute of Industrial and Systems Engineers and SME.