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Student Perceptions of Online Learning Effectiveness during the COVID-19 Quarantine

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Student perceptions of online learning effectiveness during the COVID-19 quarantine

Abstract - Limited studies exist examining the effect of the initial COVID-19 quarantine on engineering education, and those available tend to be limited to a single engineering discipline. This paper examines student perceptions of the learning experience in the emergency situation presented by the COVID-19 pandemic across four engineering disciplines. Student surveys were administered during the first and last week of the change from in-person to online instruction for 12 engineering classes, comprising five different instructors, at an undergraduate institution in the United States. A paired t-test analysis was performed to determine if pre- and post-survey mean results were significantly different for the whole group, and various genders, majors, and years of study. Results indicate that while some improvement in perception was shown, students maintained either an undecided or negative perception of the online educational environment. Significant difference between pre- and post-survey responses were seen with regards to the perception of grades, ability to identify, formulate, and solve engineering problems, and ability to function effectively on a team, with the latter two learning outcomes scoring lowest in the pre-surveys. In addition to the survey analysis, lessons learned and recommendations for effective online education are discussed. As online education becomes more popular and in some cases more necessary, it is important to understand the impact on engineering education, particularly in situations of forced distance education. This study provides insight into the challenges that come with emergency online instruction and could drive decisions on priorities for in-person learning environments.

Introduction

Higher education in an online learning environment has been shown to be at least as effective as face-to-face, is appreciated by students [1, 2, 3, 4, 5] and could lead to improved performance [6]. However, it does have limitations [7, 8, 9, 10, 11], and requires several weeks of preparation by the instructor prior to the start of class [12, 13], as well as careful consideration of how learning takes place online [14]. Further, past studies [15] have indicated student learning satisfaction was diminished when the learning environment (online or face-to-face) was switched mid-semester. In the case of the COVID-19 pandemic, most institutions around the world were forced to move to an online learning environment within a week [7, 9, 16] or two mid-semester.

Typically, students know upfront that they are signing up for an online class and may be predisposed to successful learning in this environment. However, in an emergency situation such as the COVID-19 response when classes abruptly moved online, successful implementation is more challenging. Typically for students to succeed in an online learning environment they should be self-motivated and organized [17, 10] and have a good learning environment [9]. While the literature illustrating the success of online education is plentiful [1, 2, 3, 4], initial research analyzing online education during the COVID-19 quarantine indicates that the majority of students preferred face-to-face learning and had negative perceptions toward online learning during the COVID-19 quarantine [7, 18] especially those that live in rural areas [19]. Often this was not due to technical difficulties but from lack of self-discipline, suitable learning materials, or good learning environments [9].

Few studies exist examining the effect of the initial COVID-19 quarantine on engineering education [18, 20, 21, 22, 19, 23, 24, 4, 25], and those available are not student-centered or tend to be limited to a single engineering discipline. The purpose of this paper is to analyze student perceptions of online learning during the initial COVID-19 quarantine, as well as document the changes instructors made to their class format during that time. Student perceptions have been seen to correspond with student performance in many cases [26, 27, 28] and can provide a window into student engagement [27]. In the midst of the transition, not only educators, but also students, have faced many challenges. This paper aims to document the abrupt transition from the students' perspective to shed light on challenges that must be addressed in times of emergency in higher education and in typical times where a class is being transitioned from an in-person to an online learning environment. In addition to the survey analysis, lessons learned and recommendations for effective online education are discussed.

Background

Due to the COVID-19 pandemic, our university made a sudden shift from fully in-person instruction to entirely remote online learning with less than two weeks' notice to both students and faculty. This sudden shift left faculty scrambling to convert in-person lectures, which relied heavily on chalkboards and document cameras as the interface to communicate to students in the classroom, to an entirely online format using only computers from home. The faculty decided to survey the students to obtain their perspective to determine if students thought the online instruction would be and actually was as effective as the in-person instruction. Twelve undergraduate engineering courses were surveyed both during the first week of online learning, then again at the end of the online instruction. Although the students were busy trying to adapt to the change while still maintaining class schedules, they responded well to the surveys. Close to 400 student responses were collected over the two surveys given.

Benefits and Limitations of Online Learning

Online learning has been a controversial topic among educators due to its vast range of benefits and limitations. It has been shown that benefits of online or blended classes include students being able to be constantly aware of their performance and able to identify areas that need more attention, instructors having a new level of control over a course, in grading, providing feedback, and preserving academic integrity [29]. Students enjoy the ease of access and flexibility of online learning [30, 31]. Online learning has made international collaborations possible that enhance students' interpersonal and intercultural competency skills [32, 24]. In addition, online learning is widely appreciated by learners unable to relocate for educational purposes. The flexibility and cost-effectiveness of being able to complete online learning has benefited countless individuals.

Limitations of online learning have been shown to include increased isolation resulting from reduced student-teacher and student-student interaction [7], the inability to implement some engineering lab or other hands-on activities [11, 31], increased barriers to effective communication, and the increased time required for students and instructors to complete tasks [10]. Learning perception by students has been found to be less in an online learning environment compared to in-person with regard to social presence, social interaction, and satisfaction [8]. Research continues to find and test new methods to increase the interaction between instructors and students as well as student-to-student interaction in an online learning environment.

Despite both benefits and limitations, the COVID-19 pandemic has not only forced all educators and schools to embrace online-based education but has also forced them to realize the need to optimize online education. Educators who were accustomed to in-person teacher-student interaction are now avidly searching for successful methods to aid in the abrupt transition to online learning.

Recommendations for Success

Whether educators strongly prefer online versus in-person instruction typically has a strong correlation to whether the instructor understands how to properly prepare and communicate in an online environment. Extensive research has been done [2, 9, 12, 33, 14, 31, 34, 3, 4, 25] and is continuing to improve the transition and execution of online education.

Successful online education follows the same principles as in-person education. These can be summarized with the Seven Principles of Good Practices in Undergraduate Education [35, 30]:

1. Good practice encourages contacts between students and faculty;
2. Good practice develops reciprocity and cooperation among students;
3. Good practice uses active learning techniques;
4. Good practice gives prompt feedback;
5. Good practice emphasizes time on task;
6. Good practice communicates high expectations; and
7. Good practice respects diverse talents and ways of learning.

Recommendations for implementing these principles in an online learning environment include requiring synchronous online meetings [2], having weekly online discussion sessions that promote a sense of community [2, 12, 9, 33, 18, 31, 34, 25], dividing teaching content into smaller modules to help students focus [12, 9, 14, 18, 19], having a back-up plan for unexpected issues, slowing down speech during lectures to allow students to capture key points, utilizing teaching assistants to share the extra requirements, using various methods to modify homework and reading to strengthen students' active learning outside of class, providing timely feedback to student assignments [9, 19, 31], making compelling lecture videos, establishing a presence with a welcome message, frequent notices and feedback [12], and setting and reminding often of time management expectations [12, 36]. Recommendations also include practical implementations such as ensuring the online learning platform is easy to use, works on inexpensive bandwidth that is easily available [19], is web-based, includes a drawing board functionality, is recordable, and is interactive [11].

Although the efficacy of both online and in-person learning environments have been proven, going forward from the pandemic will require all educators to learn how to adapt and embrace the change. Toquero (2020) recommends that the impacts of the COVID-19 pandemic on the educational system be documented, while Abdous and Yoshimura (2010) recommended that future studies should work to better understand the effect of the "right fit" of a student's learning style and a specific delivery method. This paper aims to document the impacts of the pandemic as perceived by the students during and after the transition.

Methods

On March 11, 2020, faculty, staff, and students were informed that Spring Break was extended by one week and that classes would resume on March 23, 2020, in a completely online learning environment. The university prides itself on its "hands-on" and personal approach to teaching, so an online learning environment was new to most instructors and students. A survey was administered in 12 undergraduate engineering courses, comprising five different instructors, using the Blackboard Learn Learning Management System within the first two weeks of the switch to online instruction asking students' perceptions about whether they expect to meet specific ABET learning outcomes, earn a better, worse, or the same grade, and if they expect they and other students would adhere to academic integrity rules. A similar survey was administered to the same students in the last week of classes. Survey results were analyzed using a paired t-test to determine if pre- and post-survey mean results were significantly different for the whole group, and different genders, majors, and the year of study.

Class Approach

Survey data were collected and analyzed across 12 engineering courses at the same university campus as listed in Table 1. Engineering disciplines across the complete surveyed population included Civil Engineering, Electrical Engineering, Mechanical Engineering, and general Engineering that included Chemical Engineering and Computer Engineering concepts. Class sizes ranged from 10 – 60 students and included first, second, third, and fourth-year students. All courses were previously taught in-person with traditional lectures, homework, exams, quizzes, team projects, and active learning exercises. Five of the classes included labs and 10 of the 12 classes traditionally had closed-book, closed-notes quizzes and exams. After the switch to online learning, all 12 of the classes used a blend of synchronous and asynchronous lectures, videos, and office hours using Zoom, and just two classes remained in a closed-book and/or closed-notes format for quizzes and exams.

CE1412 Hydrology & Water Resources: Before the switch to online, the class included synchronous in-person lectures, closed-notes and closed-book quizzes and exams, team homework, and computer-based labs. Office hours were offered in person. After the transition to online, the course followed a flipped approach with lectures recorded asynchronously and synchronous classes held on Zoom focused on answering questions from students. Quizzes and exams were changed to an open-book and open-notes format. Labs had all been completed prior to the switch to an online learning environment. Office hours transitioned to Zoom.

CE1420 Hydraulic Design: Before the switch to online, the class included synchronous in-person lectures, closed-notes and closed-book quizzes and exams, homework, computer-based labs, and a team semester-long project. Office hours were offered in person. After the transition to online, the course followed a flipped approach with lectures recorded asynchronously and synchronous classes held on Zoom focused on answering questions from students. Quizzes and exams were changed to an open-book and open-notes format. Team presentations and remaining labs were canceled, however, the reports for the team project remained. Office hours transitioned to Zoom.

CE1610 Engineering & Sustainable Development: Before the switch to online, the class included synchronous in-person lectures, closed-notes and closed-book quizzes and exams, team homework and a team semester-long project with presentations and reports. Office hours were offered in person. After the transition to online, the course followed a flipped approach with lectures recorded asynchronously and synchronous classes held on Zoom focused on answering questions from students. Quizzes and exams were changed to an open-book and open-notes format. Team presentations were canceled, however, the reports for the team project remained. Office hours transitioned to Zoom.

EE0031 Linear Circuits I: Before the switch to online, the class included synchronous in-person lectures, closed-notes and closed-book quizzes, and active learning exercises. After the transition to online, the course followed an asynchronous approach while including open-notes and open-book quizzes, a team project, and an optional final exam. Office hours transitioned to Zoom.

EE1771 Electric Machines: Before the switch to online, the class included synchronous in-person lectures, closed-notes and closed-book quizzes, homework, and active learning exercises. Office hours were offered in person. After the transition to online, the course followed an asynchronous approach while including open-notes and open-book quizzes and homework. Office hours transitioned to Zoom.

ENGR0018 Introduction to Engineering Computing: Before the switch to online, the class included synchronous in-person lectures, closed-notes and closed-book quizzes, homework, team projects, and active learning exercises. Office hours were offered in person. After the transition to online, the course followed an asynchronous approach while including open-notes and open-book quizzes, homework, and team projects. Office hours transitioned to Zoom.

ENGR0132 Statics: Before the switch to online, the class included synchronous in-person lectures, closed-notes and closed-book quizzes, homework and active-learning exercises. Office hours were offered in person. After the transition to online, the course followed an asynchronous approach while including open-notes and open-book exams and homework. Office hours transitioned to Zoom.

ME0040 Materials of Manufacturing: Before the switch to online, the class included synchronous in-person lectures, open-notes and open-book quizzes, homework, team projects, and active learning exercises such as case studies in-person mixed with online discussion forums. Hands-on labs and office hours were offered in person. After the transition to online, the course followed a synchronous approach while including open-notes and open-book quizzes, homework, and team projects. Office hours transitioned to Zoom. Lectures were also supplemented asynchronously providing lecture recordings and telecon options for those that had limited internet options. The lab component was conducted via simulations and Zoom meetings. An online discussion forum was used for case studies.

ME1053 Applied Thermodynamics: Before the switch to online, the class included synchronous in-person lectures, closed-notes and closed-book quizzes, homework, and exams. Office hours were offered in person. After the transition to online, the course followed an asynchronous approach with closed-notes and closed-book exams. Office hours transitioned to Zoom.

ME1071 Applied Fluid Mechanics: Before the switch to online, the class included synchronous in-person lectures, closed-notes and closed-book quizzes, homework, and exams. Office hours were offered in person. After the transition to online, the course followed an asynchronous approach with closed-notes and closed-book exams. Office hours transitioned to Zoom.

ME1172 CADD/CAE: Before the switch to online, the class included synchronous in-person lectures, open-notes and open-book exams, homework, a team project, and active learning exercises. Office hours were offered in person. After the transition to online, the course followed a synchronous approach while including open-notes and open-book exams, homework, and a team project. Office hours transitioned to Zoom. Lectures were also supplemented asynchronously providing lecture recordings and telecon options for those that had limited internet options.

ME1173 Finite Element Analysis: The course was taught traditionally, with all instruction held in the classroom prior to the transition. Finite Element Methods (FEM) is a Mechanical Engineering (ME) elective computer class that uses ANSYS, a numerical simulation software. Assignments were completed and classes held in the computer lab. After the transition to online, the students were surveyed, and it was found that many lacked either a computer powerful enough to run the program or adequate access to the internet. Students were given the option of completing tutorials followed by projects or pursuing research topics and writing papers.

Table 1. Course Descriptions

Course	**Course Name**	**Lab**	**Class Size**	**Pre-Survey Responses**	**Post-Survey Responses**	**Paired Survey Responses**
CE1412	Water Resources & Hydrology	Yes	35	24	20	16
CE1420	Hydraulic Design	Yes	18	15	11	9
CE1610	Eng. & Sustainable Development	No	41	19	23	11
EE0031	Linear Circuits and Systems 1	Yes	29	14	8	5
EE1771	Electric Machines	Yes	10	6	6	3
ENGR 0018	Intro. to Engineering Computing	No	34	16	15	3
ENGR 0152	Dynamics	No	37	8	5	2
ME 0040	Materials of Manufacturing	Yes	60	33	34	16
ME1053	Applied Thermodynamics	No	60	40	30	17
ME1071	Applied Fluids	No	22	16	11	6
ME1172	CADD / CAE	No	23	15	14	7
ME1173	Finite Element Methods	No	34	25	10	7
TOTAL			**403**	**231**	**187**	**100**

Survey Design

Students were asked 16 questions in an online survey through the Blackboard Learn Learning Management System. Students were first asked to create a nickname (Q1) that they would use in the pre- and post-survey. They were also asked to identify their major (Q2; mechanical, civil, electrical, or chemical engineering or undecided), year (Q3; first-year, second-year, third-year, fourth-year) and the gender (Q4) to which they identify. They were then asked a series of questions asking if they feel that they would do better, same, worse, or are undecided with regards to grade (Q5) and achieving the following individual ABET learning outcomes [37] due to the current emergency online learning environment compared to a traditional in-person class:

Q6. Gain an ability to identify, formulate, and solve complex engineering problems;

Q7. Gain an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors;

Q8. Gain an ability to communicate effectively with a range of audiences;

Q9. Gain an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgements, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts;

Q10. Gain an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives;

Q11. Gain an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions; and

Q12. Gain an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

The survey also included questions asking if the student anticipated adhering to academic integrity rules (Q13), if they felt that others would not adhere to academic integrity rules (Q14), and if the student felt that they were skilled enough in computer literacy to succeed in an online environment (Q15) or if there would be technical problems due to the online environment (Q16).

Results

Population Characteristics

As summarized in Table 2 the paired data population included four disciplines, namely Civil Engineering (CE), Chemical Engineering (ChemE), Electrical Engineering (EE) and Mechanical Engineering (ME). Of the four disciplines the majority was ME at 61% and CE at 36%. 84% of the students identified as male, 15% female, and 1% identified as agender. Fourth-year students made up 39% while 36% were third-year and 22% were second-year students. The first-year class had a 3% share, all part of ENGR 0018. These demographics and engineering disciplines are representative of the overall engineering population at this campus and the total surveyed population.

Table 2. Paired Dataset Population

Course	Gender			Major				Year			
	Female	Male	Agender	CE	ChemE	EE	ME	1	2	3	4
CE 1412	1	15	0	16	0	0	0	0	0	11	5
CE 1420	3	6	0	9	0	0	0	0	0	3	6
CE 1610	1	10	0	10	0	0	1	0	1	8	2
EE 0031	0	5	0	0	0	0	5	0	4	1	0
EE 1771	0	3	0	0	0	2	1	0	1	0	2
ENGR 0018	1	2	0	0	1	0	2	3	0	0	0
ENGR 0152	1	1	0	1	0	0	1	0	2	0	0
ME 0040	2	14	0	0	0	0	16	0	13	3	0
ME 1053	3	14	0	0	0	0	17	0	1	10	6
ME 1071	0	4	0	0	0	0	4	0	0	0	4
ME 1172	1	6	0	0	0	0	7	0	0	0	7
ME 1173	2	4	1	0	0	0	7	0	0	0	7
TOTAL	**15**	**84**	**1**	**36**	**1**	**2**	**61**	**3**	**22**	**36**	**39**

Student Perceptions on Learning Outcome Expectations

Figure 1 shows that while post-survey responses were consistently higher than pre-survey responses, all mean values were less than two illustrating that on average students maintained either an undecided or negative perception of the online educational environment (0: Worse; 1: Undecided; 2: Same; 3: Better). The difference between pre- and post-survey was significant (P-value < 0.05) for Q5 (Grade), Q6 (Ability to identify, formulate, and solve complex engineering problems), and Q10 (Ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives), but averages were still around 1.5 or below.

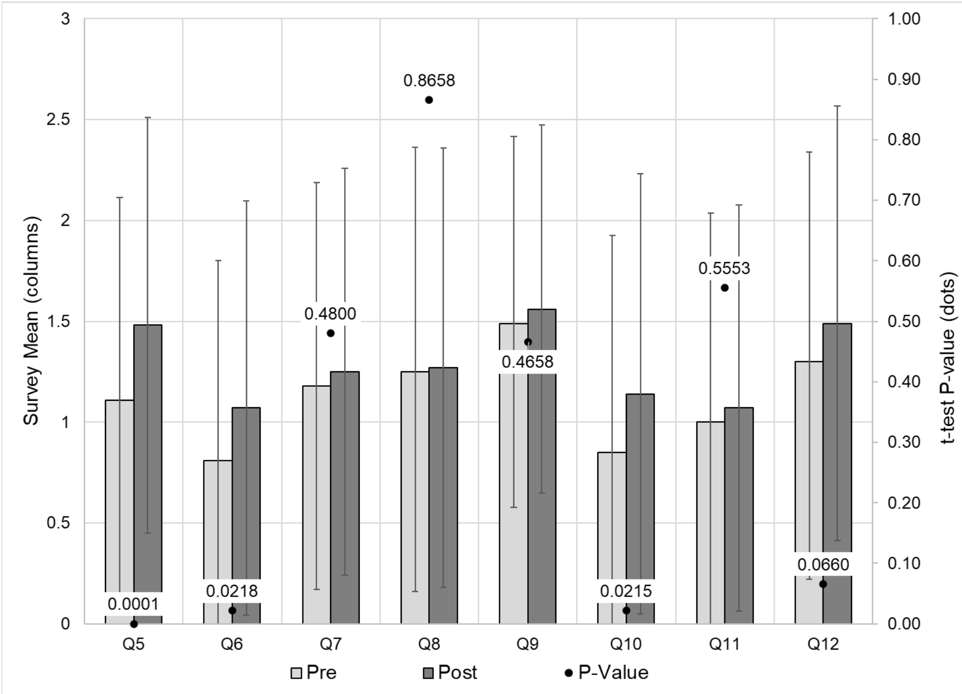

Figure 1. Paired T-Test Results. Bars represent pre- and post-survey means, error bars represent one standard deviation, and black dots represent t-test P-values for the difference between pre- and post-survey means. Survey mean scores represent student perceptions (0: Worse; 1: Undecided; 2: Same; 3: Better) related to grades (Q5) and learning outcome expectations (Q6-Q12).

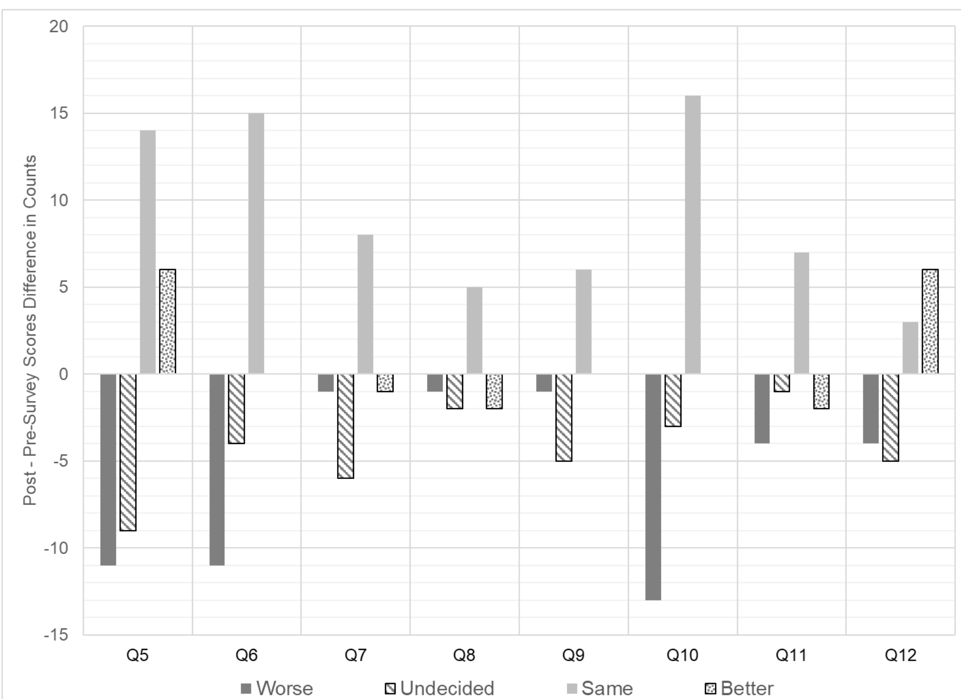

Figure 2. Post – Pre-Survey Difference in Survey Score Counts. A negative value indicates more students chose that score in the pre-survey than in the post-survey.

Figure 2 illustrates the difference in counts between post- and pre-survey scores. A negative value indicates more students chose that score in the pre-survey than in the post-survey. This was the case for all questions in the Worse and Undecided categories, showing at least one student answered each question with a higher rating in the post-survey compared to the pre-survey. Similarly, more students answered in the "Same" category for all questions in the post-survey compared to the pre-survey. Q5 and Q12 also showed that more students answered in the "Better" category in the post-survey than in the pre-survey.

When survey responses were categorized according to gender, men showed improved perception across all survey questions while women's responses were mixed as shown in Figure 3. Men represented 84 responses and women just 15, most likely indicating why men's responses follow the same trends as the whole data analysis. One survey response was agender and was not included in the gender analysis due to the small sample size. Statistical difference was seen in the men's responses for Q5, Q6, and Q10, as in the whole data analysis, with the addition of a statistical difference in Q12 (Ability to acquire and apply new knowledge) when the men's responses were separated from the women's. None of the women's pre- and post-survey mean responses were significantly different. Post-survey responses between men and women were significantly different for Q6 (P-value 0.0496) and Q9 (P-value 0.0227), with men having a higher mean (1.14) than women (0.6) for Q6 (Ability to identify, formulate, and solve complex engineering problems) and women having a higher mean (1.93) than men (1.48) for Q9 (Ability to recognize ethical and professional responsibilities and make informed judgments).

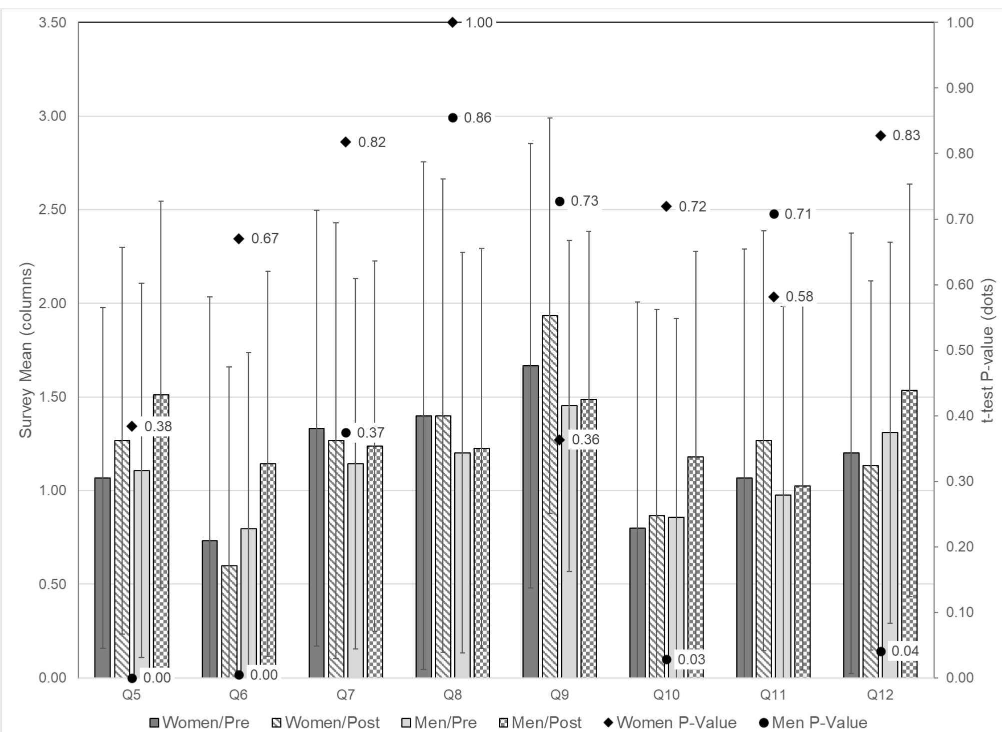

Figure 3. Paired T-Test Results for Men and Women. Bars represent pre- and post-survey means, error bars represent one standard deviation, and black dots represent t-test P-values for the difference between pre- and post-survey means. Survey mean scores represent student perceptions (0: Worse; 1: Undecided; 2: Same; 3: Better) related to grades (Q5) and learning outcome expectations (Q6-Q12).

Survey responses categorized according to major also indicated significant improvement in mean scores for Q5 for both civil (n=36; P-value 0.005) and mechanical engineers (n=61; P-value 0.015). Electrical and chemical engineering majors were excluded from this analysis due to the small sample size. Post-survey responses between civil (mean 1.97) and mechanical engineers (mean 1.16) were significantly different as well (P-value 7.06E-05) for Q5. Civil engineering majors also showed a significant difference in pre- and post-survey responses for Q6 (P-value 0.0049). No other questions showed a significant difference in mean pre- and post-survey responses when categorized according to major.

Differences in mean survey responses were further analyzed for Q5 categorizing the data according to the year of study and course. Second (n=22) and third-year (n=36) students showed a significant difference in mean pre- and post-survey responses. The sample size for first-year students was too small (n=3) for a meaningful analysis, and fourth-year students (n=39) did not show a significant difference between pre- (mean 1.15) and post-survey (mean 1.35) responses. CE1412 (n=16) did show a significant difference between pre- (mean 1.25) and post-survey (mean 2.00) mean responses for Q5, while CE1610 (n=11), CE1420 (n=9), ME0040 (n=16), and ME1053 (n=17) did not. Other courses were not analyzed due to the small sample size.

Discussion

Overall, students at this campus did not expect the sudden change to an online learning environment to be effective. A large influence in this perception is likely to be the culture of this campus and the type of learner that it attracts. The campus prides itself on being “hands-on” with close, personal interaction between professors and students. Professors know students by name and frequently have one-on-one, face-to-face contact with them. Before COVID-19, online engineering education on this campus was nonexistent. This was thus a big adjustment for both students and faculty.

The findings in this research do show that the online learning environment did go better than students expected, though they still did not perceive it to be as effective as in-person. This is evident with mean post-survey responses being consistently higher than mean pre-survey responses for all questions, and significantly so for Q5, Q6, and Q10. However, all mean survey scores were still around 1.5 or below indicating most students felt online learning was worse or they were undecided. This highlights the challenges with teaching in an online environment and the need for time and training for instructors to adequately prepare.

Students’ perceptions of gaining communication skills (Q8) showed the lowest improvement, as shown in Figure 2, though the pre-survey mean was already greater than one. This could be due to many presentation assignments being canceled with the sudden switch to online learning. As faculty and students became more comfortable with the online environment in the Fall 2020 semester, student presentations were required more regularly. Gaining the ability to recognize ethical and professional responsibilities and make informed judgments (Q9) scored the highest in both the pre- and post-surveys. Students perceived learning how to solve complex engineering problems (Q6) and gaining teamwork skills (Q10) to suffer the most in the pre-survey with mean scores less than one but showed a significant difference from the post-survey scores as shown in Figure 1. In the post-survey scores, Q6 and Q10 means raised to above 1 indicating that most students were at least undecided on the effectiveness of the online learning environment rather than thinking it was worse. Even in the Fall 2020 semester with some students remote and others in-person, it was evident that students are not comfortable working in teams remotely. They do not yet seem to have the skills to plan accordingly so that team members can meet remotely and still effectively and efficiently complete team projects. This is an important learning outcome, as now more than ever, engineering professionals need to work in teams remotely and even globally. Finally, student work involving experimentation, such as in labs (Q11), is not surprisingly the biggest challenge in converting to an online learning environment along with Q6. Student perceptions of these outcomes faired the worst in the post-scenario survey (mean score 1.07) and are most likely the biggest challenges for faculty.

Time should be taken upfront in an online learning environment to teach students how to succeed in this environment. Learning tips such as active participation in synchronous classes either through chat or by unmuting, turning on video cameras to help with a personal connection with the instructor and other students, and frequent and active participation in asynchronous discussion boards should be highlighted to students.

In the Fall semester, students were asked to share in an online discussion board their advice on how to succeed in an online learning environment. The most frequent recommendation was to limit distractions by finding a quiet learning environment and putting away your cell phone. Students also consistently recommended adhering to the same routine and discipline as you would for an in-person class, such as waking up an hour before class, dressing and showering for class, and sitting at a desk and taking notes during class. While inducing students to participate in an online class is challenging for the instructor, students did recommend active participation to be successful. Their recommendations in this area included attending synchronous classes rather than solely relying on recorded lectures, obtaining a webcam and microphone so you can participate in class, and participating in class through chat or unmuting yourself. Students also discussed how keeping up with work and deadlines seemed to be more challenging in an online learning environment, so staying organized, checking the Learning Management System daily to stay apprised of due dates, assignments, quizzes, and exams, and studying for exams and quizzes a few days in advance as you would if they were in-person were of particular importance. Many students also appreciated now having recorded lectures due to the online learning environment, not just to provide flexibility if a synchronous class was missed, but to rewatch to get clarification on confusing topics and review prior to assessments. Recommendations related to well-being were also discussed by students such as spending time away from the computer screen when not doing school work, having fun, connecting with other students, and keeping a positive attitude.

It is interesting to note that the following Fall semester, students and faculty were given the choice to attend classes in-person or via Zoom as the COVID-19 pandemic continued but the lock-down ceased. Even when the instructor chose to teach in-person, typically less than half the students chose to attend in person. As the semester continued, fewer students attended in person. In informal interviews, some students stated that they saw little difference in remote or in-person learning, while others could tell a substantial difference.

Conclusions

In this study, student perceptions for a sudden transition into an online learning environment during the initial COVID-19 quarantine are analyzed. Despite ample evidence that online learning can be effective and appreciated by students, the abrupt and forced change to an online learning environment during the COVID-19 quarantine added additional challenges for instructors and students. Overall, students either did not feel that the learning environment was as effective as the in-person environment to which they were accustomed or were undecided.

Since not all students are predisposed to learning effectively in an online environment, where self-motivation, discipline, and a distraction-free learning environment are highly necessary, time needs to be taken to teach students how to learn in this environment. This may be through requirements such as cameras on during synchronous lectures, regular participation in discussion boards, or active oral or written participation during synchronous lectures. Students need to understand and take responsibility for their learning, even more so in the online learning environment, and instructors need to be able to convey this requirement to their students and support them in learning how to do this.

Limitations of the study include that it was entirely done on a single campus that is a teaching-focused campus that prides itself on a personal, hands-on approach. Not only are students used to in-person learning but the instructors are as well. The change to an online learning environment was not only not ideal but it goes against what instructors at this campus feel are the best way to teach and learn. Because this was something no one was used to, survey results were negative. After students experienced the actual online environment perceptions went up, and most likely would continue to improve as students become accustomed to the new environment. Faculty perceptions were not formally surveyed as part of this study, nor were student grades compared. These are all opportunities for further research.

Further research includes analysis within classes and a comparison of student grades between in-person and online learning environments. A study to discover faculty perceptions and challenges is also planned in the future. Expanding the study to various types of learning institutions would be worthwhile. Also, extending the study to discover how student and faculty perceptions change as the online and hybrid learning environments continue at this campus is planned.

Recommendations from this study on educational practice include extensive opportunities for faculty to learn and connect with other faculty for best practice sharing, particularly in a fully remote scenario. In addition to formal online classes to learn online teaching tools, faculty workshops focused on sharing best practices for ensuring academic integrity were held in the Fall 2020 semester. These workshops were found to be particularly effective in not only learning best practices but enhancing a sense of community that is easily lost when most are working remotely. This lack of community can extend into the classroom, if not actively addressed. Flipped classroom techniques such as using asynchronous recorded lectures to allow time for synchronous lectures to be used for student activities such as team project working sessions in breakout rooms have been shown to be appreciated by students. It is also challenging for instructors to determine if students are understanding material when they cannot see faces or body language, and few students interact. Opportunities for active learning are even more important and must be thoughtfully built into the online classroom, such as with breakout rooms, live surveys such as through Poll Everywhere, or requiring participation through the chat window.

Overall, students who struggle to keep up with work in-person will struggle even more in an online environment. Personal motivation and accountability are even more important for students in an online learning environment and go hand-in-hand with maturity. Faculty are challenged to support students who struggle in these areas and help them to grow. As online education becomes more popular and in some cases more necessary, it is important to understand the impact on engineering education, particularly in situations of forced distance education. This study provides insight into the challenges that come with emergency online instruction and could drive decisions on priorities for in-person learning environments.

Appendix 1. Consent/Waiver.

You are being invited to participate in a research study titled "Emergency On-Line Instruction". The purpose of this study is to obtain information about your background and perceptions of learning in this emergency on-line instruction environment. We hope to use this information to improve our curriculum and response in emergency situations. In addition, we will share the aggregate results in presentations and/or publications. This questionnaire will ask about *your perception of learning in THIS class*. You may be asked to submit this survey in more than one class. You may have different answers for different classes. The survey will take you approximately *five* minutes to complete.

We believe there are no known risks associated with this research study; however, as with any research activity the risk of a breach of confidentiality is always possible. To the best of our ability your answers in this study will remain confidential. We will minimize any risks by only asking you to provide a **nickname**. This way, your responses will not be matched with your identity. Also, **your professor will not know whose answers connect to which survey or who completed the survey**. Finally, the data will be disposed of after five years per American Psychological Association regulations.

Your participation in this study is completely voluntary and you can withdraw at any time. You are free to skip any question that you choose. If you choose not to participate it does not affect your relationship with your professor or result in any other penalty or loss of benefits to which you are otherwise entitled. We greatly appreciate your assistance with this important study. Thank you!

If you have questions about this project or if you have a research-related problem, you may contact your professor for this class. By submitting this survey, I affirm that I am 18 years old or older, and I agree that the information may be used in the research project described above.

Appendix 2. Pre-Survey.

1. Nick Name: _______________ (Please choose something that you can remember at the end of the semester)

2. Please select one to indicate your major:

□ Civil Engineering, □ Mechanical Engineering, □ Chemical Engineering
□ Computer Engineering, □ Electrical Engineering, □ Computer Science
□ Undecided/Other

3. Please select one to indicate your class:

□ Freshman, □ Sophomore, □ Junior, □ Senior

4. Gender identity (select all that apply):
   __ agender
   __ genderqueer/gender fluid/non-binary
   __ man
   __ questioning or unsure
   __ trans man
   __ trans woman
   __ woman
   __ prefer not to disclose
   __ additional gender category/identity not listed

For each question, indicate with an 'X' if you feel that you will do better, same, worse or are undecided about the identified skill or measure.

	Better	Same	Worse	Undecided
5. Grade				
6. Ability to identify, formulate, and solve complex engineering problems				
7. Ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors				
8. Ability to communicate effectively with a range of audiences				
9. Ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts				

10. Ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives				
11. Ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgement to draw conclusions				
12. Ability to acquire and apply new knowledge as needed, using appropriate learning strategies				

For each question, indicate your response with an 'X' .

	Yes	No	Maybe
13. Do you anticipate adhering to academic integrity rules (e.g., not accessing Chegg, other people, or other resources) during ordinarily proctored closed-book, closed notes quizzes and exams with the emergency on-line course structure?			
14. Do you feel that others may not adhere to academic integrity rules putting you at a disadvantage with the emergency on-line course structure?			
15. Do you consider yourself skilled enough in computer literacy to succeed in an on-line environment?			
16. Do you anticipate that there will be technical problems due to the on-line environment?			

Appendix 3. Post-Survey.

1. Nick Name: _______________ (Please choose the same name you used in the PRE_SURVEY)

2. Please select one to indicate your major:

□ Civil Engineering, □ Mechanical Engineering, □ Chemical Engineering
□ Computer Engineering, □ Electrical Engineering, □ Computer Science
□ Undecided/Other

3. Please select one to indicate your class:

□ Freshman, □ Sophomore, □ Junior, □ Senior

4. Gender identity (select all that apply):
   __ agender
   __ genderqueer/gender fluid/non-binary
   __ man
   __ questioning or unsure
   __ trans man
   __ trans woman
   __ woman
   __ prefer not to disclose
   __ additional gender category/identity not listed

For each question, indicate with an 'X' if you feel that you will do better, same, worse or are undecided about the identified skill or measure.

	Better	Same	Worse	Undecided
5. Grade				
6. Ability to identify, formulate, and solve complex engineering problems				
7. Ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors				
8. Ability to communicate effectively with a range of audiences				
9. Ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts				

10. Ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives				
11. Ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgement to draw conclusions				
12. Ability to acquire and apply new knowledge as needed, using appropriate learning strategies				

For each question, indicate your response with an 'X' .

	Yes	No	Maybe
13. Did you adhere to academic integrity rules (e.g., not accessing Chegg, other people, or other resources) during ordinarily proctored closed-book, closed notes quizzes and exams with the emergency on-line course structure?			
14. Do you feel that others did not adhere to academic integrity rules putting you at a disadvantage with the emergency on-line course structure?			
15. Do you consider yourself skilled enough in computer literacy to succeed in an on-line environment?			
16. Did you encounter technical problems due to the on-line environment?			

References

[1] M. Abdous and M. Yoshimura, "Learner outcomes and satisfaction: A comparison of live video-streamed instruction, satellite broadcast instruction, and face-to-face instruction," *Computers & education,* vol. 55, no. 2, pp. 733-741, 2010.

[2] J. M. Allen and F. Vahid, "Experiences in Developing a Robust Popular Online CS1 Course for the Past 7 Years," in *ASEE Annual Conference*, 2020.

[3] S. F. Shady, "Approaches to teaching a biomaterials laboratory course online," *Journal of Online Engineering Education,* vol. 12, no. 1, 2021.

[4] A. S. F. Sobrinho, "An embedded systems remote course," *Journal of Online Engineering Education,* vol. 11, no. 2, 2020.

[5] L. Vitoria, M. Mislinawati and N. Nurmasyitah, "Students' perceptions on the implementation of e-learning: Helpful or unhelpful," *Journal of Physics: Conference Series,* vol. 1088, 2018.

[6] A. Singh and A. K. Min, "Digital lectures for learning gross anatomy: a study of their efficacy," *Korean Journal of Medical Education,* vol. 29, no. 1, pp. 27-32, 2017.

[7] S. Abbasi, T. Ayoob, A. Malik and S. I. Memon, "Perceptions of students regarding E-learning during Covid-19 at a private medical college," *Pak J Med Sci,* vol. 36, 2020.

[8] S. Bali and M. Liu, "Students' perceptions toward online learning and face-to-face learning courses," *Journal of Physics: Conference Series,* 2018.

[9] W. Bao, "COVID-19 and online teaching in higher education: A case study of Peking University," *Hum. Behav. & Emerg. Tech.,* pp. 113-115, 2020.

[10] L. Kinney, M. Liu and M. A. Thornton, "Faculty and student perceptions of online learning in engineering education," in *119th ASEE Annual Conference and Exposition*, 2012.

[11] S. Maheshwari, B. Zheleva, V. Rajasekhar and B. Batra, "e-Teaching in pediatric cardiology: A paradigm shift," *Annals of Pediatric Cardiology,* vol. 8, no. 1, pp. 10-13, 2015.

[12] S. Bakrania and L. Bakrania, "A transition from face-to-face to an online delivery, in nano steps," in *ASEE Annual Conference*, 2020.

[13] C. M. Muller-Karger and L. Steiner, "Dynamics Online Course: A Challenge content delivered with best teaching practices keeps students engaged," in *ASEE Annual Conference*, 2020.

[14] T. Govindasamy, "Successful implementation of e-Learning Pedagogical considerations," *The Internet and Higher Education,* vol. 4, pp. 287-299, 2002.

[15] H. He, H. K. Hunt and J. Strobel, "Switching Modalities: An Empirical Study of Learning Outcomes and Learners' Perceptions in a Hybrid Bioengineering Course," *International Journal of Engineering Education,* vol. 36, no. 3, pp. 901-918, 2020.

[16] A. Skulmowski and G. D. Rey, "COVID-19 as an accelerator for digitalization at a German university: Establishing hybrid campuses in times of crises," *Human Behavior and Emerging Technologies,* 2020.

[17] S. A. Ariandurai and R. Manohanthan, "Instructional strategies in teaching engineering at a distance: Faculty perspective," *The International Review of Research in Open and Distributed Learning,* vol. 9, no. 2, 2008.

[18] A. E. Felder, B. Bilgin, J. Hummel, F. Mashayek, R. A. Revelo, V. Caliskan, A. Flowers, C. Kanich, S. Lee, K. Reddy and Y. Siow, "Online Engineering Education in Response to COVID-19: Overview of Challenges in the United States and Proposed Active Learning Strategies," *International Journal of Engineering Education,* vol. 37, no. 6, pp. 1470-1478, 2021.

[19] A. A. Bakhsh, A. K. A. B. Rizwan, E. H. Abualsauod and G. C. Altamirano, "Implications of COVID-19 on Student Learning Satisfaction (SLS): A Remedial Framework for Universities," *International Journal of Engineering Education,* vol. 37, no. 6, pp. 1582-1593, 2021.

[20] E. J. A. Prada, "The Impact of "Going Virtual" on Engineering Education During the COVID-19 Pandemic: A Student-Centered Study in Columbia," *International Journal of Engineering Education,* vol. 37, no. 6, pp. 1511-1517, 2021.

[21] V. S. Rangel and J. Henderson, "An Exploratory Analysis of the Impact of COVID-19 on Engineering Programs and Undergraduate Students," *International Journal of Engineering Education,* vol. 37, no. 6, pp. 1553-1566, 2021.

[22] S. Sastre-Merino, C. N.-D.-R. Ma, A. Caravantes and J. Luis Bravo-Ramos, "Perceptions of Engineering Faculty Members of Online Teaching Due to COVID-19," *International Journal of Engineering Education,* vol. 37, no. 6, pp. 1567-1581, 2021.

[23] Rodriguez-Rivero, Rocio, A. Diaz Lantada, L. Ballesteros-Sanchez and J. Juan, "The Impact of Emergency Remote Teaching on Students' Stress and Satisfaction in Project-Based Learning Experiences," *International Journal of Engineering Education,* vol. 37, no. 6, pp. 1594-1604, 2021.

[24] L. Magpili, "Factors promoting online distance educational programs for international students and the impacts of the Covid 19 pandemic," *Journal of Online Engineering Education,* vol. 09, no. 20, 2020.

[25] N. A. Libre, "A discussion platform for enhancing students interaction in the online education," *Journal of Online Engineering Education,* vol. 12, no. 2, 2021.

[26] Z. Unal and A. Unal, "Comparison of student performance, student perception, and teacher satisfaction with traditional versus flipped classroom models," *International Journal of Instruction,* vol. 10, no. 4, pp. 145-164, 2017.

[27] L. Nathanson, R. Cole, J. J. Kemple, J. Lent, M. McCormick and M. Segeritz, "New York City School Survey 2008-2010: Assessing the Reliability and Validity of a Progress Report Measure," Online Submission, 2013.

[28] M. L. Goldschmid, "The Evaluation and Improvement of Teaching in Higher Education," *Higher education,* pp. 221-245, 1978.

[29] S. Papanikolaou, "E-Learning and Assessment in the Cloud: Engineering Courses," in *ASEE Annual Conference*, 2020.

[30] D. A. Kwary and S. Fauzie, "KwaResultados e opiniões dos alunos sobre a implantação do ensino a distância em aulas de fonética e fonologia na Universidade Airlangga," *Educação e Pesquisa,* vol. 44, no. e173240-e173240, 2018.

[31] M. Jarvie-Eggart, "What students value about education and recommendations for online education," *Journal of Online Engineering Education,* vol. 8, no. 1, 2017.

[32] P. Appiah-Kubi and J. Nichwitz, "Students' Perception of Collaborative Online International Learning," in *ASEE Annual Conference*, 2020.

[33] P. Panindre and R. S. Thorsen, "Assessment of Learning Effectiveness in Online and Face-to-Face Learning Environment for Engineering Education," in *ASEE Annual Conference Proceedings*, 2020.

[34] A. M. Doggett, "Online learning preferences of engineering technology management graduate students," *Journal of Online Engineering Education,* vol. 5, no. 1, 2014.

[35] A. W. Chickering and S. C. Ehrmann, "Implementing the seven principles: Technology as lever," *AAHE bulletin,* vol. 49, pp. 3-6, 1996.

[36] T. Daymont, G. Blau and D. Campbell, "Deciding between traditional and online formats: Exploring the role of learning advantages, flexibility, and compensatory adaptation," *Journal of Behavioral and Applied Management,* vol. 12, no. 2, pp. 156-175, 2011.

[37] ABET, "Criteria for Accrediting Engineering Programs, 2019 – 2020," 2019. [Online]. Available: https://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2019-2020/#GC3. [Accessed 2020].

[38] C. M. Toquero, "Challenges and opportunities for higher education amid the COVID-19 pandemic: The Philippine context," *Pedagogical Research,* vol. 5, no. 4, 2020.