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Learning from the Student Experience: Impact of Shelter-in-Place on the Learning Experiences of Engineering Students at SJSU

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Dr. Backer been a faculty at SJSU since 1990 and held positions as an assistant professor, associate professor, professor, department chair, and director. Since coming to San Jose State University in 1990, she been involved in the General Education program and conducts research into pedagogy and STEM education. Currently, Dr. Backer serves as the PI for SJSU's Title III Strengthening grant both from the U.S. Department of Education.

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Maria Chierichetti joined the department of Aerospace Engineering as a full-time assistant professor in Fall 2019. Her interests lie in the field of aerospace structural design and vibrations, with particular emphasis on developing methodologies for combining finite element analysis and machine/deep learning for structural health monitoring and unmanned Structural inspections in the context of urban air mobility. Maria is also interested in investigating how students learning is affected by external factors, such as COVID-19 pandemic and community service. Before joining SJSU, she worked as a faculty member at Worcester Polytechnic Institute and at the University of Cincinnati. She earned her PhD at Georgia Tech in 2012 working on the monitoring and tracking of helicopter blade deformation. She earned a BS and MS from Politecnico di Milano (Italy) in 2004 and 2007 respectively, with majors in Aeronautical Engineering. She is an Amelia Earhart Fellow – Zonta International Foundation.

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Learning from the student experience: Impact of the shelter-in-place on the learning experiences of engineering students at San José State University

Abstract

This is a research paper based on an in-depth study of the impact of COVID-19 on students and faculty in the San José State University (SJSU) College of Engineering completed in Spring and Summer 2020. In this paper, we report on the interviews we did with 40 students from the College. In March 2020, SJSU moved all of its classes to remote learning for the remainder of the Spring term. The students included freshmen (3 students), sophomores (2 students), juniors (7 students), seniors (11 students) and graduate students (17 students). During the interviews, the students reported more negative experiences with their classes after the move to remote learning as compared to positive experiences with 32 of the 39 students reporting at least one negative experience. The students had many comments related to course content including project work in the Spring 2020 semester (28 students), online tests and exams (27 students), lab issues (23 students) and PowerPoint use and issues (13 students). Also, approximately one-third of the students responded that their instructors did not respond to emails from students. Most students showed appreciation for the efforts that faculty made in the quick transition to remote learning. However, the students expressed concerns about the organization of the classes (13 students), the lack of interactivity (9 students) and the availability of lecture videos (9 students). More than half of the students gave recommendations as to how faculty could improve their remote classes in Fall 2020. Many faculty, according to the student interviews, were unprepared to teach remotely. They had difficulties in using the learning management system (LMS), Canvas, as well as Zoom. As well, some faculty would not record their lectures or not post them online. The student comments can give faculty insight into improving their classes in the future.

Introduction

The outbreak of COVID-19 in the world has caused many universities to move their classes to emergency remote learning. Instead of being a planned movement, this shift to remote instruction was quick. At San José State University (SJSU), students and faculty were given less than one week to prepare to teach and take classes remotely. Most faculty at SJSU had never taught online before this dramatic shift in March 2020 and both faculty and students were challenged to finish the semester. Most SJSU engineering classes are offered in the traditional face-to-face mode with in-person laboratories and project classes. Because of COVID-19, all SJSU classes, including those in the College of Engineering, went to a remote mode.

The object of this study was to determine the impact of the sudden move to remote learning on engineering students at SJSU through a survey and interviews. By supplementing the surveys with interviews of students, this study hopes to provide insights to engineering educators about classes taught in a remote teaching mode as well as strategies to make in-person classes more effective. In this paper, we focused on the following research questions.

1. What is the impact of COVID-19 on student learning for engineering students at SJSU?
2. What are student perceptions towards emergency remote learning?

3. What aspects of remote learning worked best and least for students in engineering?
4. What can faculty do to improve both remote and face-to-face learning environments?

Review of the Literature

Since the move online because of COVID-19 in the United States, there have been many surveys of students to determine their attitudes towards this change. MindWires [1] is keeping a list of student surveys on its website. As of April 2021, they have links to 29 surveys that have been completed with 500 to 76,000 respondents. In this paper, the authors are going to summarize the surveys that are most relevant to the current research.

Digital Promise and Langer Research Associates surveyed a randomized nationwide sample of 1,008 undergraduates, 717 attending four-year colleges and 271 attending two-year colleges, whose classes were converted from in-person to remote learning after the COVID-19 pandemic hit [2]. They found that student satisfaction in the emergency remote learning mode was lower than for in-person classes and students “struggled to stay motivated and missed receiving feedback from instructors...” (p. 3) This finding agrees with other surveys. One survey by Simpson Scarborough [3] of 513 students in March 2020 found that, among college students who took the survey, “63% say online instruction is worse than the in-person instruction they received at their school.” A second survey at the Harvard School of Dental Medicine [4] found that students reported that “their learning has worsened since the move to e-learning, with 44% of students responding ‘somewhat worsened’ and 26% answering ‘significantly worsened.’”

Ithaca S+R, in partnership with 21 universities across the U.S., developed a student survey focused on institutional communications and support, curricular needs, safety and well-being, and fall retention [5]. 15,677 students completed the survey. The student responses agreed with the Digital Promise [2] results. Students in the Ithaca S+R survey rated the following activities as somewhat or very difficult for them: balancing family, school and household activities, time management, adjusting to remote learning, and finding a quiet place to work. Another nationwide survey was conducted by the Higher Education Data Sharing Consortium [6]. More than 42,000 students from 65 colleges and universities participated in this survey. 48% of students reported a great deal of stress because of COVID-19. Students in this survey indicated several worries including doing well in college, accessing and using the technology required, paying bills, and having a safe place to sleep at night.

San José State University (SJSU), as an institution, completed a survey of the impact of COVID-19 on all students at SJSU [7]. Of the 33,685 enrolled students in Spring 2020, 4,571 students completed the survey. Students indicated some concerns about their move to emergency remote instruction. Only about half of students reported being satisfied with the emergency remote courses and 57% of undergraduate students and 42% of graduate students reported that stress had impacted their academic success in Spring 2020 a lot.

Despite these surveys, there were only a few that focused on engineering students. Another campus in the California State University (CSU) system, CSU Long Beach, conducted a survey of engineering after the move to remote learning in Spring 2020 [8]. They received completed surveys from 110 faculty and 627 students from six engineering departments. The researchers

found that students had several challenges during Spring 2020. “About 70% of students indicated difficulty in maintaining their focus or experiencing Zoom fatigue after attending multiple online sessions...64% did not feel engaged during the online classes. 60% of the students felt there was a lack of clear guidance or communication from the instructors” (p. 4). A survey by Serhan [9] at another university in the U.S. confirmed the issues with Zoom. Serhan found that students had negative attitudes towards the use of Zoom in their classes during the COVID-19 pandemic and the students believed it was having a negative effect of their learning. Another survey including engineering students was done at the University of Bacau, Romania [10]. 135 students (including 99 engineering students) completed the survey. Overall, they found that students (59.2%) wanted more flexibility in remote classes. Also, students reported it was difficult for students (47.4%) and faculty (34.8%) to adapt to this way of learning.

The University of Georgia (UG) conducted qualitative research on engineering students and faculty after the emergency remote learning change and found that faculty were adapting better to the move online than were students. The UG study was based on 23 stories collected from faculty (11), staff (2), undergraduate students (8), and graduate students (2). The student stories were highly negative and the students felt that they were treated with indifference, they had difficulty in communicating with instructors, and they felt that the new instructional methods were impersonal [11].

Son et al [12] conducted an interview study about the impact of COVID-19 at a large university in Texas. Despite being a survey of all students, 60% of the students were engineering majors. Of the 195 students interviewed, 71% indicated increased stress and anxiety and 89% reported difficulty in concentrating. With reference to their academic performance, 82% were concerned about their academics being affected by the pandemic with the biggest challenge being the move to 100% remote classes (38%); students were concerned about changes to the syllabus, the quality of their classes during the remote learning, technical issues with remote learning, and the difficulty in learning 100% online. Another qualitative study was completed at the University of San Diego [13]. Gelles et al interviewed eleven engineering students in Spring 2020 about the transition to remote learning. The researchers found several challenges that students perceived. The three challenges that were most described by the students were increased workload, ineffective learning environments, and miscommunication. Also, the students reported Zoom fatigue and distraction which agree with the CSU Long Beach [8] and Serhan [9] research findings. Most critical to instructors, however, was that the students reported that they felt they could not get help in an online class compared to a regular classroom. Because all of the participation was through Zoom, students felt uncomfortable asking questions of the professor.

Disappointment with the learning environment among engineering students is echoed in research conducted on postgraduate students in the United Kingdom [14] and 140 undergraduate engineering students in Qatar [15]. Out of the eleven students interviewed in the UK study, eight were postgraduate students in engineering or technology. Participants in the U.K. study, in agreement with the Gelles et al study [13], felt that the remote classes were merely direct transfers of the existing teaching in the class rather than reconfigurations of the teaching to maximize the effectiveness. The instructors adopted digital technologies “as a replacement for the missing physical learning environments, with the learning process remaining the same. This resulted in ineffective learning when compared to traditional face-to-face learning environments”

(p. 294). 82 students in the Qatar study participated in written reflections about their experiences and eight students were interviewed. The students felt that the emergency remote learning environment needed to “be supported by teaching activities that involve more participation through interactive activities and teamwork” [15, p. 13]. Overall, the surveys and interviews showed that the quality of instruction suffered after the move to remote teaching in Spring 2020.

Methodology

The results in this paper are part of a larger study completed at SJSU that looked at the impact of COVID-19 on students and faculty [16-18]. The College of Engineering at SJSU is one of the largest in the CSU system. There were 6,674 students who were enrolled as engineering majors in Spring 2020; each of these students was sent a survey about their experiences after all the classes at SJSU went online in March 2020. One of the last questions in the survey asked for volunteers to participate in an interview. 129 students volunteered to be interviewed as of June 30, 2020. Because of the high number of volunteers, we went through the students that volunteered for the interview and picked four students per major (if there were at least 4 volunteers). The strategy we followed was as follows

- if volunteers < 4, we took them all
- if > 4, we divided them in three categories (1: Frosh+Soph+Junior, 2: Senior, 3: Grad) and picked one student for categories 1 and 2, and two students from the graduate students. To do so, we assigned them a random number between 0-1 and picked the student with highest number for each category

Overall, we chose 50 students to be interviewed in June 2020. We contacted the students by email and set up Zoom meetings in July and August 2020 to interview the students who replied. 26 of the 50 students set up Zoom interviews with one of the co-authors. After we closed the student survey on 7/16/20, we downloaded additional students who had agreed to be interviewed—28 additional students overall. We decided to replace the students who did not reply to our emails with the additional students who volunteered. In our replacement, we looked at four variables: grade level, major, gender, and ethnicity. Our first choice was to replace a nonresponsive student who matched on all four variables and our second choice was to replace a nonresponsive student who matched on three of the four variables. Table 1 shows the distribution of our student pool from the initial selection to the final selection. Overall, we completed interviews with 40 engineering students.

Table 1. Distribution of Students Selected to be Interviewed

	Original 6/2020	Revised 7/2020		Original 6/2020	Revised 7/2020
Female students	16	15	Frosh + Sophomore + Junior	13	13
Male students	34	34	Senior	13	14
other		1	Graduate	23	22
			other		1

Student Interview Protocol

For this interview, the interview protocol was informed by the protocol was used by Pawley [19] at Purdue University. The interview recordings were completed through Zoom and recorded on the Zoom cloud. When this is done, Zoom automatically creates a transcript of the Zoom video.

The transcripts were reviewed by graduate students for typos in the transcript and words that were transcribed incorrectly. The researchers then pseudonymized the transcript, masking names, places, ages, organizations, ethnic groups (replacing them with broader racial categories), nationalities, languages, and religious affiliations or communities for those participants who desired it and the names of people participants mentioned. One of the researchers sent the participants the pseudonymized transcripts to review for inaccuracies or things they regretted saying. The interviewee could make whatever changes they wanted in the transcript.

The interview protocol is below. The interview consists of a single question: “How did you do in your classes in Spring 2020?”. According to Pawley, this allows “participants to tell their stories in whatever way they chose” (p.18). We have included the prompts below for this protocol.

Interview guide

1. How did you do in your classes in Spring 2020?

Prompts as needed: Tell me a little about yourself. Tell me about your experiences at SJSU after the transition to 100% online instruction. How did your instructors teach your engineering classes after going online? Has COVID-19 made any impact on your life? Did you take any lab classes? How did they go?

2. Prompts on institutional structures—financial, community service, student support, rules and regulations at SJSU

Generic prompts: Let’s talk about that for a minute; Tell me more about that; So, just to clarify...How did you learn about this? What was important to you? Any regrets? Anything you wish you had done differently? Anything else you would like to tell me?

According to Piyatamrong, Derrick, and Nyamapfene [14], semi-structured interviews “encourage two-way communication for comprehensive, open-ended thoughts and opinions related to the topic” (p. 293). We wanted to use open-ended questions to encourage the students to express their feelings and sentiments about the abrupt move to online classes in Spring 2020. This open-ended approach has more flexibility than more focused questions and provides the interviewee with diverse ways to give feedback.

After the transcripts were cleaned and approved by the interviewee, we analyzed the transcripts. We used NVivo 12, a qualitative data analysis tool, to code the student interviews. One of our team members first hand-coded the interview data transcripts and then employed a coding scheme in order to look for emergent themes or domains of meanings or meaningful patterns across the interviews. Open coding was used by the interview team leader to explore the transcripts and remain open to different interpretations of the data [20]. The student interviews were independently coded by a graduate student. The two coders worked together to categorize and reorganize the coding into larger categories. The categories and codes were discussed iteratively over a several week period to allow each of the two coders to provide different perspectives.

The main limitation of the current analysis stands in the limited number of participants which represents a small portion of the total number of students in the SJSU College of Engineering. In addition, the participants were self-selected as they volunteered to be interviewed. When there were enough participants in a major, we randomly selected the students from the students who offered to participate in the interview process. These limitations are common practice for

qualitative analysis. All interviews were conducted by one of the authors, which is a white female engineering educator, an engineering education researcher and an advocate for active learning and active communication. This epistemological commitments and positionality of the interviewer might have affected the follow up questions asked to the participants, although the interviewer kept the follow up questions as consistent as possible.

Results

The student interviews were conducted in July and August 2020. Overall, we interviewed 40 students using Zoom. To pseudonymize the students and protect their identities, we used the list of 2018-2020 Atlantic Hurricanes to rename the participants [21]. The names alternate from male to female and we followed the same procedure. Because we interviewed 40 students overall, we used the cyclone names from 2018-2020. Table 2 shows the major, ethnicity, year, and gender of the students whose transcripts we analyzed for this study. One student's transcript was not included because the student did not take any engineering classes in Spring 2020. Instead, this student took classes for a business minor.

Table 2. Students interviewed about their experiences in Spring 2020.

Pseudonym	Major	Ethnicity	Year	Gender
Joyce	Aerospace Engineering	Two or more ethnicities	Lower Division	Binary
Fernand	Aerospace Engineering	Latinx	Upper Division	Male
Sebastien	Aerospace Engineering	Asian American	Graduate	Male
Tony	Aerospace Engineering	Latinx	Graduate	Male
Debby	Aviation	White	Upper Division	Female
Michael	Aviation	Two or more ethnicities	Upper Division	Male
Ernesto	Aviation	White	Upper Division	Male
Nadine	Biomedical Engineering	Latinx	Lower Division	Female
Sara	Biomedical Engineering	International	Graduate	Female
Kirk	Biomedical Engineering	Two or more ethnicities	Graduate	Male
Gordon	Chemical Engineering	White	Lower Division	Male
Florence	Chemical Engineering	White	Upper Division	Female
Arthur	Civil and Environmental Engineering	Asian American	Upper Division	Male
Patty	Civil and Environmental Engineering	Latinx	Upper Division	Female
Andrea	Civil and Environmental Engineering	International	Graduate	Female
Leslie	Civil and Environmental Engineering	Middle Eastern	Graduate	Female
Barry	Computer Engineering	Latinx	Upper Division	Male
Humberto	Computer Engineering	Latinx	Upper Division	Male
Van	Computer Engineering	Asian American	Graduate	Male
Valerie	Computer Engineering	International	Graduate	Female
Helene	Electrical Engineering	White	Upper Division	Female
Isaac	Electrical Engineering	White	Lower Division	Male
Lorenzo	Electrical Engineering	International	Graduate	Male
Nestor	Electrical Engineering	International	Graduate	Male
Chantal	Human Factors/Ergonomics (in ISE)	Decline to state	Graduate	Female
William	Industrial & Systems Engineering (ISE)	Latinx	Upper Division	Male
Pablo	Industrial Technology	International	Upper Division	Male
Dorian	Industrial Technology	Latinx	Upper Division	Male
Gonzalo	Industrial Technology	African American	Upper Division	Male
Jerry	Industrial Technology	Latinx	Upper Division	Male
Alberto	Materials Engineering	White	Graduate	Male
Oscar	Mechanical Engineering	Middle Eastern	Lower Division	Male

Cristobal	Mechanical Engineering	African American	Upper Division	Male
Edouard	Mechanical Engineering	African American	Upper Division	Male
Erin	Mechanical Engineering	Asian American	Graduate	Female
Gabrielle	Mechanical Engineering	Asian American	Graduate	Female
Rafael	Mechanical Engineering	Middle Eastern	Graduate	Male
Chris	Mechanical Engineering	White	Graduate	Male
Imelda	Software Engineering	African American	Upper Division	Female
Beryl	Software Engineering	White	Graduate	Female

We interviewed students from each major in the SJSU College of Engineering with the exception of students from General Engineering. General Engineering is the smallest program in the college; in Spring 2020, there were only 73 students in General Engineering of the 6,372 students in the college overall. We divided the students into three groups: lower division students (Freshmen and Sophomores), Upper Division students (Juniors and Seniors) and Graduate students. As described in our methodology section, we purposely used a stratified approach to our selection of the interviewees so that we would get representation from all of the departments.

After the transcripts were coded using NVivo 12 software, we evaluated the frequency of the coding. Overall, we generated 35 different codes based on the student interviews. Table 3 shows the codes, the number of student interviews with the code, and the number of total references. The highest theme that was present was “negative experience.” 32 of the 39 students who were interviewed indicated that they had at least one negative experience in the Spring 2020 semester related to their engineering classes. The next highest codes were Project work in Spring with 28 student interviews including this code and online tests and exams with 27 student interviews including this code. Interestingly, the next highest code was “positive experience” with 25 student interviews including a positive experience. The closeness of negative experiences and positive experiences show the dichotomy for many students about remote learning. For most students, they had classes and instructors that did a good job and others who did not.

Table 3. Frequency of Coding in the Spring 2020 Student Interviews

Code	Number of Student Interviews	Number of Total References
Student Sentiments		
Negative Experience	32	89
Positive Experiences	25	47
Student Comments Related to Course Content		
Project Work in Spring	28	41
Online Tests and Exams	27	75
Lab Issues	23	40
Powerpoint usage and issues	13	18
Student Recommendations for Improving Instruction		
Recommendations for faculty	20	32
Instructors should be better organized and be able to use technology	13	14
Classes could be more interactive	9	9
Videos should be available after class	9	14
Instructor refused to record or post lectures	9	12
Student Negative Comments		
Instructor lectured the entire period	18	33
Instructor did not respond to emails from students	13	19

Instructor did not conduct classes after COVID/instructor missed several classes	7	11
Instructor did not hold office hours	7	10
After COVID, classes were (should be) more flexible	8	10
Instructor could be more understanding	5	6
Instructors want students to work more	4	4
Instructor thought students were cheating	4	4
Students cheated	3	4
It was hard to talk to instructor during office hours	3	4
Class did not meet at scheduled time	1	2
Student Positive Comments		
Instructor used active learning	16	24
Instructor responded to students via email or in office hours	9	11
Instructor tried very hard in the online class or used Canvas effectively	6	7
Instructor used a whiteboard	4	5
Students Personal Experiences in Spring		
Spring was a lot of stress	20	34
Students miss social interactions and work with other students	12	20
Student did not like online learning	9	14
Important thing is to reduce risk from COVID	9	10
Student needs to be more proactive in online classes	8	9
Other Comments		
Graduation issues	5	5
Job search and internship issues	3	6
Internet, computer and connectivity issues	3	3
Student has learning disability	1	2

Student Sentiments

During the interviews, the students were direct in discussing their concerns about the instruction during Spring 2020. Almost all of the comments under Negative Experience dealt with the students' experiences with their classes in Spring 2020. 32 of the 39 students interviewed had at least one negative experiences in Spring 2020 after instruction went to a remote mode. Some of the comments related to the way the class were taught (Gonzalo--“ I can't say that I did learn in the class, even though it was online. Half of the class was a lab and I didn't feel like I learned as much as the lab than the lecture.”). Other comments related to office hours (Florence--“On top of that, answering emails is a big thing for me like I had a professor in the spring quarter. He was really good about answering emails for a little bit and then towards the end. I would send him follow up emails like hey did you get this, and I never got a reply.”). Many related to online testing (Jerry--“We had a midterm, midterm, number two. That had some graphics on it, and for some reason the Canvas LockDown Browser wouldn't show any of the graphics. So, when it came time to the answer that question, we would just see a blank page with like the letter A and B, and it was completely confused.”).

At the same time, many students reported positive experiences in their classes after the emergency move online in March 2020. Overall, 25 of the 39 students reported a positive experience. The positive experiences usually were reported by the same students who had negative experiences. These positive experiences were related to the ways that the faculty conducted classes as well as supports that the faculty members gave the students. This finding

agrees with the research by Gelles et al [13] who found, despite the problems that students reported, that they “appreciated the effort and how adaptable” the engineering professors were. The students liked having the videos available after class so that they could review them. As Erin noted, “He recorded his screen. He went through a PowerPoint on the screen and wrote on something similar to a whiteboard on his screen, where applicable to solve problems. So that was how he was giving us instructions. He would record it, uploaded on canvas, and then we could access it at any time and just view it as a video within Canvas.” Also, despite disliking the overuse of PowerPoints for lecture presentation, the students appreciated when the slides were well-done and understandable. Gordon said “He was outstanding. All of his PowerPoints were fluid. It looked very easy, very appealing. So I had no issues whatsoever with math. It felt as if I was in his classroom as normal.”

Student Comments Related to Course Content

The largest number of student comments, related to course content, including project work in the Spring 2020 semester (28 students), online tests and exams (27 students), lab issues (23 students) and PowerPoint use and issues (13 students). As expected, projects and lab work were challenging for the students and instructors after SJSU mandated emergency remote learning. Despite the challenges, most of the students were able to complete their projects after the move online.

The main issue with project work was related to the senior projects for undergraduate engineering majors. At SJSU, most seniors in engineering complete a two-course sequence for their senior projects. The Fall semester is focused on designing the senior project with the Spring semester dedicated to the building of the project. Many groups did not finish their senior project work before SJSU mandated remote learning and they had to finish their projects theoretically in most cases.

Approximately two-thirds of the students reported issues with labs during remote learning. Many instructors either omitted the labs from their classes or did the experiments themselves and shared the results with the students in the class. Also, there were many issues related to online tests and exams. Overall, very few students enjoyed the online tests. The tests ranged from take-home exams to proctored exams using lockdown browsers. Among the students who talked about lockdown browsers, the experiences were negative. Valerie’s comments are typical of the students’ opinions about lockdown browsers. “Many students faced challenge with the proctorU exam, due to technical difficulties they were not able to begin exam for about an hour...During proctorU exam, we were not able to communicate to our professor to ask any doubts in the question, I lost 12 points in one of the midterm exam, because I accidentally closed the proctorU chat window and got panicked whether university not able to monitor me and what if my exam got invalid. So clicked submit exam before completion.”

Students had mixed feelings about the use of PowerPoint in their classes during remote learning. From the interviews, it appears that many instructors used PowerPoint for their entire class time. Patty’s comment is typical of the comments of the other students with respect to Powerpoint use. “Yeah, he would kind of just like read through the PowerPoint, but it was kind of confusing. Because the exercises that we would follow with, they just, I don't know if they just didn't if they

were missing some portions in his PowerPoints, but it was, it was kind of hard to, it was hard to get the proper instruction to do the exercises to understand the material.”

Student Recommendations for Improving Instruction

Most students appreciated the efforts that faculty made in the quick transition to remote learning. But, the students expressed concerns about the organization of the classes (13 students), the lack of interactivity (9 students) and the availability of lecture videos (9 students). More than half of the students gave recommendations as to how faculty could improve their remote classes in Fall 2020. Many faculty, according to the student interviews, were unprepared to teach online. They had difficulties in using the learning management system (LMS), Canvas, as well as Zoom. Students overwhelmingly wanted access to class videos for review purposes. According to Imelda, “So it's kind of required to attend lecture, but he also said he didn't know how to like work like dealing with the zoom transcripts and stuff but I did attend every lecture link all my classes, which was fine for me. But it was hard because that class was already tough as it is and like having to refer back to the book, instead of like the like videos or PowerPoints was like, I don't know, too tedious.”

Student Negative Comments

Not surprisingly, considering that most students expressed at least one negative sentiment, the largest number of different comments were negative. A large number (18 out of 39 students) reported that, in at least one of their classes, that instructors lectured the entire period. Most classes at SJSU are scheduled for either twice a week for 75 minutes or once a week for 2.5 hours. This complaint about extensive lecturing also was found in a study of software engineering students during the COVID-19 pandemic [22] at the University of Glasgow. At Glasgow, students had just begun an intensive eight-week block of classes when the classes moved to an emergency remote mode. The instructors found that two-hour live lectures were tedious for both the instructor and students. In our interviews, the problem of too long lectures was evident in the student comments. Rafael's comment is typical of the students' feelings about lectures for an entire period. “The online lectures for the master's program, they are pretty long. You know, like, because they do this two days per week and then two hours or sometimes three hours in one day, that, I think, I don't know like the professors need to be more creative or more like find different ways for these lectures. Because two hours just watching the PowerPoint slides, we lose focus.”

Approximately, one-third of the students responded that their instructors did not respond to emails from students. The loss in communication between the instructors and students was shown also in the number of instructors who did not hold office hours after the switch to emergency remote instruction in Spring 2020. According to SJSU policies, full-time instructors must hold 3 hours of office hours each week; the amount of office hours is reduced for part-time instructors. The students felt this lack of communication deeply. Before the move online, most lecturers would stay after class to answer the questions from students. After the move to remote learning, this changed. According to Kirk, a Masters student, “And so both of them were working you know, and industry so you know, I felt both my classes were in the evenings there from six to nine, you know, from 6:00 to 8:45 at nighttime. Right and so both professors were

working during daytime. And so they didn't have, you know, office hours, or they would be on campus normally”

Student Positive Comments

Despite the general negative impressions that students had during Spring 2020, there were accolades for instructors who did well online. Over 1/3 of the students had at least one class that used active learning during remote instruction (16 students). Some faculty used features in Zoom or Canvas to do active learning online while others had students complete group assignments during class. Gonzalo gave an example as to how active learning was used in one of his classes. “There was a difference, the professor in the other technical elective class really provoked us to ask more questions. So he will know that we were we were paying attention and we were learning. It was also, we also had it more than once a day. I feel like that really helps with online classes. And it's not just all in one chunk but spread out, that's very helpful, and for the professor to check to see how engaged the students are.”

Discussion

The students struggled in many ways after SJSU mandated the move to emergency remote learning in Spring 2020. They had issues with the instructors' teaching, the remote learning environment, and personal issues. The students felt that the instructors did not realize the impact of teaching the same way in remote learning as they did in in-person class. Also, the students believed that the instructors did not realize the stress they were under. Students hoped that the Fall 2020 semester would be better organized and taught in a more student-friendly way.

Much of the results from our survey and student interviews agree with other research studies on the impact of COVID-19 on university students in Spring 2020. Our student interviews indicated that students had more negative impressions than positive ones about their experiences in Spring 2020 after the switch to emergency remote teaching. 32 of the 39 students interviewed had at least one negative experiences in Spring 2020 after the move to remote learning. Some of the comments related to the way the class were taught, other comments related to office hours, and others related to online testing. Overall, many students did not like remote instruction. This agrees with the study by Means and Neisler [2] who found that student satisfaction after moving to remote learning was lower than for in-person classes. When we compared our results with another study on CSU engineering students by Asgari et al [8], we found similar challenges for students. However, since we conducted in-depth interviews with 39 engineering students, we were able to expand on this research to provide a more nuanced analysis of the engineering student experience.

The effectiveness of online instruction depends on a well-designed educational experience including the instructor's engagement in the online class and lecturer-to-student and student-to-student interactions [23]. Because of the quick move to remote learning for SJSU, as well as other institutions, the environments in most classes did not maximize the potential for student learning. At SJSU, there was little training until Summer 2020, so the instructors in Spring 2020 had to make rapid decisions on how to change their classes for remote instruction. This transition was difficult for many instructors and, initially, there were a lack of resources for faculty in the

transition. As Kapilan, Vidhya and Gao [24] noted, faculty development programs are crucial for effective teaching in engineering courses, particularly lab classes.

The research literature on prior unplanned crisis (for example, Hurricane Katrina, Great East Japan Earthquake) is clear that effective communication is crucial for student success during a crisis that interferes with normal university classes [25-27]. Accurate communication is important from both the university as well as the instructor. In our interviews, approximately one-third of the students responded that their instructors did not respond to emails from students. Also, the instructors of seven of the interviewed students did not hold office hours during emergency remote instruction. This lack of communication was distressing to students and left them feeling lost. Now, as more universities are planning to move classes to in-person or hybrid modes in Fall 2021, the need for clear communication with students should not be forgotten.

At SJSU, prior to Spring 2020, there were few engineering classes taught in a fully online mode. The educational crisis brought on by COVID-19 has led to a dramatic revision in the way that courses were taught, both at our institution and nationwide. However, best practices in teaching online have generally been passed over in the need to put a class online. Despite increasing research on active learning, the teacher-centered lecture model still persists in STEM fields. Research has shown that active learning can reduce achievement gaps between under-represented students and White students [28]. In this study, Theobald et al conducted a meta-analysis of research on active learning which included data on student examination scores from 15 studies (9,238 total students) and data on student failure rates from 26 studies (44,606 total students). One finding from this study is the importance of including active learning in STEM classrooms. It is the authors' perspective that active learning also should be the predominant mode in online and traditional face-to-face classes.

Although the shift to remote teaching was made quickly in Spring 2020, this experience has shown that teaching engineering classes online has benefits. The most crucial aspect to implement in online teaching is student engagement and motivation [29]. It is time for engineering faculty to accept that online education is a viable alternative for in-class instruction. SJSU is a Hispanic serving institution. As an HSI located in one of the most ethnically diverse locations in the United States, it is important for us to redesign our teaching to improve the outcomes for students from all backgrounds.

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