

Understanding the Impacts of COVID-19 on Feelings of Stress and Anxiety in Women Engineering Students

Dr. Maija A. Benitz, Roger Williams University

Dr. Maija Benitz is an Assistant Professor of Engineering at Roger Williams University, where she has taught since 2017. Prior to joining RWU, Benitz taught at the Evergreen State College in Olympia, WA, after completing her doctoral work jointly in the Multiphase Flow Simulation Lab and the Wind Energy Center at UMass Amherst. She teaches in the first-year curriculum, as well as thermodynamics, sustainable energy, fluid mechanics, and ocean engineering. Benitz is a Hassenfeld Community Engagement Fellow and a Diversity and Inclusion Fellow at RWU. Her research focuses on offshore wind energy, oyster growth, community engagement, and engineering education.

Dr. Lillian Clark Jeznach, Roger Williams University

Dr. Lillian Jeznach is an Assistant Professor of Engineering at Roger Williams University. She teaches the first year curriculum as well as courses related to environmental and water resources engineering. She received a Bachelors of Science in Environmental Engineering at Worcester Polytechnic Institute and received her Master of Science and a Ph.D. in Civil Engineering from the University of Massachusetts, Amherst. Dr. Jeznach's research focuses on the analysis of water quantity and quality in both natural and built hydrologic systems. She is also a Diversity and Inclusion Faculty Fellow at RWU and interested in evaluating evidence-based teaching and mentoring practices in STEM education, particularly those which may increase retention of underrepresented students in the engineering discipline.

Dr. Selby M. Conrad, Roger Williams University

Selby Conrad, Ph.D. is an Assistant Professor at Roger Williams University, Adjunct Assistant Professor (Clinical) at Brown University Medical School and a licensed psychologist on staff at Rhode Island and Bradley Hospitals. Dr. Conrad's program of research has largely been focused on gender differences in risk and recidivism within the juvenile justice system. However, she also conducts research in gender differences in educational experience and risk in college students and substance use in a variety of populations. Her clinical work is focused on youth with co-occurring disorders. She teaches undergraduate and graduate students in applied areas such as counseling skills, art therapy and research methods.

Understanding the Impacts of COVID-19 on Feelings of Stress and Anxiety in Women Engineering Students

Abstract

For over two decades, the percentage of women earning bachelor degrees in engineering has remained stagnant at 20%, despite continued growth in the overall number of undergraduate engineering degrees awarded in the US. Understanding how to increase both recruitment and retention is critical to improving the representation of women in engineering. Beyond the interest in drawing more women to engineering majors, the literature cites many reasons for why women choose to leave engineering programs. For example, feelings of worry, discouragement, and anxiety are shown to inhibit learning and academic progress, in ways that disproportionality affect women, and can lead to exiting an engineering program. In the fall of 2018, we piloted a study to better understand differences between women, men, and non-binary engineering students at our liberal arts university in the northeastern US. The survey is administered twice each academic year to explore self-efficacy, belongingness, preparedness, and engagement, both longitudinally and cross-sectionally. In March 2020, our university quickly pivoted to remote learning in response to the outbreak of COVID-19 and in the fall of 2020 our campus re-opened for hybrid learning. The abrupt changes in higher education, brought on by the current public health crisis, affect students' learning and mental health, in ways that will likely be long lasting. To measure the impacts of the pandemic on engineering students, twenty Likert-type screener questions were added to the survey, which was re-administered in June 2020 and again in September 2020. This paper shares findings from the two most recent survey points, with emphasis on the results from the COVID screener questions. Women reported significantly higher levels of stress on ten out of the twenty COVID screener questions, as compared to the men, spanning topics related to home life, physical health, mental health and academics. Fewer significant changes were observed over time in men than women. This study aims to provide insights on how to better recruit, retain and support women in undergraduate engineering programs through measuring differences in feelings of stress and anxiety between genders and across time.

Introduction

The COVID-19 pandemic forced a quick pivot to online learning in engineering programs during the spring of 2020 and has continued to affect engineering education during the 2020-2021 academic year. The transition to remote learning was particularly difficult for many of the hands-on experiential learning and laboratory courses that are integral parts of an engineering education. Very few engineering programs in the United States offer purely remote learning environments for engineering students, and so this kind of teaching and learning was new for both faculty, rapidly adjusting their curriculum in a short amount of time, and for the students

who had to quickly adapt their learning styles [1]. In addition, most students across the country left their campuses and returned home to complete the spring 2020 semester from afar, leading to fewer interactions with their peers, faculty, and staff for educational support.

Engineering students, like many other students across the country, had to adapt very suddenly to an unfamiliar learning environment, and this was fraught by many challenges. A national survey at the end of spring 2020 semester indicated that in general the biggest challenge for undergraduate students was staying motivated in a remote environment without the structure of the classroom and instructors and peers [2]. Students also indicated that learning was more difficult without hands-on experiences and that it was difficult to engage with remote material [2]. In general, undergraduate engineering students are not accustomed to remote instruction and much of the challenges to students revolved around adapting to this new all-digital medium, with all-digital communication [3]. Managing these adaptations was often made more difficult by internet issues, access to hardware and software, and the stressors of working and learning in the home [2]. Such stressors were felt disproportionately by low-income students, putting them at a learning disadvantage compared to their more affluent peers [2] [3].

The pandemic has perpetuated and exaggerated many of the inequities existing in higher education (for both faculty and students) particularly along the lines of gender, race, and income. Higher rates of anxiety and depression were observed among women students, as well as lower income students, students of color, non-binary students, LGBTQ students, and students who are caregivers [4]. Since the start of the pandemic, women have shouldered a disproportionate burden of home and childcare duties resulting in less work productivity [5] [6]. During the spring of 2020, women engineering students reported more stress about home, personal, and family challenges including anxiety about family members losing jobs or having to take care of loved ones [7]. The same students found themselves more responsible for domestic tasks in the time they were not completing coursework, compared to their male peers who described themselves as having more free time [7]. In the classroom, women engineers expressed the desire to use the Pass/Fail option and wanted more compassionate and flexible pedagogy options [7].

The impacts on self-confidence and self-efficacy of engineering students during this pandemic, particularly for under-represented students, have not yet been studied but will be important for understanding predictors for online learning success. Differences in self-confidence and self-efficacy between well-represented and underrepresented engineering student populations pre-COVID has been well studied and is often used as a predictor of student retention and graduation [8]. The transition to remote learning may have impacted all college students' self-confidence and self-efficacy, as was observed in grade twelve students [9]. With the change in learning environment, all students may feel less confident about their abilities to complete work and maintain their academic performance [9]. Although most students may be very adept to using a computer for social media communication, they may have felt limited by their computer and internet self-efficacy when required to use these tools for learning. The lack of physical hands-on experiences and laboratories as well as the social interactions between peers and faculty to help

learn material may have also played a role in the decreased self confidence in academic performance that was reported by students [2] [9]. Students who were more confident despite the struggles and challenges brought by the pandemic were more likely to have greater levels of self-efficacy [9].

The changes in course delivery and the psychological stressors that students faced during the spring and fall of 2020 semesters are likely to continue to have long and substantial effects on engineering students [1]. Such effects will likely be reflected in student perceptions of their learning experience as well as their well-being, mental health, and retention in engineering programs [10] [11] [12]. In a spring 2020 survey of nine public research universities (30,725 undergraduates), 35% of students screened positive for a major depressive disorder and 39% screened positive for generalized anxiety disorder based on the PHQ-2 and GAD-2 screening tools [4]. Such results are consistent with the reported loss of motivation by students in completing coursework reported in other national surveys and disengagement with classes and university activities [2]. These relatively high rates of anxiety and depression in students are also probably highly correlated with loss of support networks such as physical interactions with peers, faculty, and staff, as well as campus wellness resources. These campus support networks play an important role in the retention and success of underrepresented populations on campus.

The abrupt change to remote learning in the spring of 2020 may be the beginning of a continued integration of online learning components into engineering education into the future. Therefore, it is important to understand the effects of an online education on student learning and mental health for future engineering education. What strategies can faculty use to effectively teach in this environment? What supports do students need both academically and for well-being? How do these needs change with gender, race, and income? There is much to learn about what practices and programs are effective for student learning and what can be further implemented which may help improve the mental health and well-being of all students.

Goals of this Study

The aim of the study is to better understand the differential impacts on women and men in an undergraduate engineering program due to changes in higher education as a result of the ongoing pandemic. The onset of COVID-19 in the United States in March 2020 necessitated abrupt changes to teaching and learning in higher education, which continued into the following academic year. This study analyzes responses from undergraduate engineering majors at a private liberal arts university from two survey time points following the onset of COVID-19 in the US. The newly collected data builds on four previous surveys administered pre-pandemic. This work explores the impacts of the pandemic on undergraduates' mental health and in particular the differences between women and men. Findings about differential experiences of stress, anxiety and worry in men and women will provide insight on how educators can better support, recruit, and retain undergraduate women in engineering.

Methods

This work is a continuation of a study that was piloted in the fall of 2018. Each semester – in the early fall and late spring – a survey is administered to undergraduate engineering majors at a private liberal arts university with the aim of better understanding differences in preparation, performance, and mental health experiences of women, men and non-binary students. The goal is to identify ways in which educators can better recruit, retain and support students in undergraduate engineering programs. Students are invited to participate anonymously in the online survey, which is incentivized with online gift cards. The survey includes questions about demographics, high school preparation, and college performance. Additionally, various mental health screeners, such as The Longitudinal Assessment of Engineering Self-Efficacy (LAESE) [13], the Youth Risk Behavior Surveillance System (YRBSS) [14], the Global Appraisal of Individual Needs Short Screener (GAIN-SS) [15], and the HOPE scale [16].

Following the spring 2020 semester, which students completed remotely as a result of the pandemic, a special survey was administered to gather data about participants' mental health. The survey was administered in mid-June and included newly added COVID-19 family stress screener questions developed by Bock [17], as well as questions created by the authors of this work. This fall, the regularly scheduled survey included the COVID-19 screener questions as well. This work examines results from the summer and fall 2020 surveys, cross-sectionally and longitudinally, with specific focus on the COVID-19 screener questions.

Participants

Undergraduate students identified as engineering majors at the time of the survey, or any time preceding the survey, at a liberal arts university in the Northeastern US were invited to participate. All participants were age 18 or older. The percentage of women engineering majors in this program is generally around 20%.

The engineering program grants Bachelor of Science degrees in Engineering, where students select a specialization in civil, computer, environmental, electrical, mechanical or a custom area. Of the survey participants, about 50% were specializing in mechanical engineering, another 25% in civil engineering, and the remaining students were evenly distributed between computer, electrical and custom specializations.

Ninety-three students participated in the survey in the summer of 2020, and 119 students completed the fall 2020 survey. Survey participants primarily identified their race/ethnicity as white, which is consistent with the overall engineering program demographics. In the summer and fall of 2020, 33% and 30% of participants were women, respectively. The participation rate of women in the study is slightly higher than the representation of women in this engineering program (~20%). The demographic data from survey participants are provided in Table 1.

Table 1. Demographic data from survey participants in summer 2020, fall 2020 and totaled across both survey time points.

| | | Summer 2020 | Fall 2020 | Total |
|-----------------------|--------------------|-------------|-----------|------------|
| Gender | Women | 31 | 36 | 67 |
| | Men | 61 | 80 | 141 |
| | Transwomen | 1 | 1 | 2 |
| | Transmen | 0 | 2 | 2 |
| | Nonbinary | 0 | 0 | 0 |
| | Other | 0 | 1 | 1 |
| Class Standing | First-years | 1 | 21 | 22 |
| | Sophomores | 17 | 35 | 52 |
| | Juniors | 18 | 28 | 46 |
| | Seniors | 49 | 32 | 81 |
| | Other | 0 | 2 | 2 |
| Race/Ethnicity | Asian | 2 | 3 | 5 |
| | Black | 0 | 3 | 3 |
| | Latinx | 4 | 12 | 16 |
| | Middle Eastern | 1 | 0 | 1 |
| | Native American | 0 | 0 | 0 |
| | Pacific Islander | 1 | 0 | 1 |
| | White | 85 | 103 | 188 |

In addition to basic demographic data, survey participants were asked to self-report their high school and college grade point averages (GPAs). A summary of the responses is provided in Table 2. T-tests were performed to measure statistical differences between GPAs across men and women. Highly significant differences ($p < 0.01$) were found between women and men's GPAs in both high school and college. Results indicate that women arrive in the engineering program with stronger academic performance and maintain that stronger performance throughout college. Future work will explore whether longitudinal shifts exist in GPAs due to the pandemic, with specific emphasis on differences across the genders. The GPA data reported here highlight differences between genders from data collected across multiple survey points, without the granularity of effects from the pandemic.

Table 2. Self-reported grade point averages from high school and college.

| | Women mean (sd) | Men mean (sd) | p-value |
|-----------------|--------------------|------------------|----------|
| High School GPA | 3.834 (0.349) ^^ | 3.539 (0.424) ^^ | 2.57E-06 |
| College GPA | 3.469 (0.475) ** | 3.274 (0.455) ** | 0.008 |

Note: ^^ indicates a highly significant difference ($p < 0.01$) high school GPA across genders, and ** indicates highly significant differences ($p < 0.01$) in college GPA across genders.

Results

Survey participants were asked to respond to ten prompts from the COVID-19 Family Stress Screener [17] with an additional ten prompts designed by the authors. The additional items were developed to measure factors that faculty were hearing anecdotally from students, but could not support or deny without stronger evidence. For example, during academic advising meetings, many students shared anxieties about lower than usual course grades and stress over the challenge of connecting with faculty members remotely. Some items were motivated by observed differences in student work, which faculty surmised was due to the added challenges students faced in working collaboratively on homework, projects, and in study groups.

The survey prompts were preceded by the following statement:

The current coronavirus (COVID-19) outbreak is causing extra stress for many people, including families with children of all ages. We would like to know how things are going for you and your family related to this situation. Please answer the following questions about your experiences and feelings over the last few weeks, using the following scale.

| | | | | |
|-------------------|-------------------|----------------------------|----------------|----------------|
| 1 | 2 | 3 | 4 | 5 |
| Strongly Disagree | Somewhat Disagree | Neither Agree nor Disagree | Somewhat Agree | Strongly Agree |

Each prompt began with the phrase “Because of COVID-19 related events and changes, I have felt increased stress about” and participants responded on a Likert-type scale to indicate their level of agreement. The full list of prompts is shown in Table 3. Mean Likert-scale scores are examined to better understand the differing experiences of stress among women and men across both survey time points.

Differences across Genders

First, the summer and fall time points were combined to perform a cross-sectional analysis of responses to the COVID-19 screener questions. The mean scores from women and men are provided in Table 3, alongside the difference between the two population means. The difference between women and men’s mean scores is consistently positive across all twenty screener questions, indicating that women consistently felt greater levels of stress about home life, career, physical health, mental health, and academics compared to the men. In general, the mean scores were highest, for both men and women, for academic related prompts.

To better understand these differences, t-tests were performed for every item with the null hypothesis that the two population means are equal. The null hypothesis was rejected for ten out of twenty screener items. Significant differences ($p < 0.05$) were found between men and women in two of the survey items, and highly significant differences ($p < 0.01$) were found in eight of the items. Single and double asterisk notation are used in Table 3 to denote significant and highly significant differences, respectively. Responses that were significantly different between the

genders spanned a range of topics, including issues relating to home life, career, physical health, and academics.

Table 3. Mean scores from men and women’s responses to COVID-19 screener questions, including difference (delta) and p-value from t-tests.

| Question: Because of COVID-19 related events and changes, I have felt increased stress about: (1 = strongly disagree, 2 = somewhat disagree, 3 = neither agree nor disagree, 4 = somewhat agree, 5 = strongly agree) | Women: mean score | Men: mean score | Delta mean: women - men | p-value |
|--|--------------------------------|------------------------------|--|----------------|
| Food running out or being unavailable | 2.127 | 1.907 | 0.220 | 0.2255 |
| Losing a job or decrease in family income | 3.413 | 2.864 | 0.548 | 0.0113* |
| Housing or utilities | 2.508 | 2.288 | 0.220 | 0.2843 |
| Loss of or limited childcare | 1.714 | 1.709 | 0.005 | 0.9767 |
| Taking care of children, including those who are normally in school | 2.063 | 1.814 | 0.250 | 0.1919 |
| Tension or conflict between household members | 3.476 | 2.602 | 0.874 | 0.000043** |
| Physical health concerns for me or a family member | 3.683 | 3.161 | 0.522 | 0.0201* |
| Increased anxiety or depression | 3.841 | 3.068 | 0.773 | 0.0005** |
| Reminders of past stressful/traumatic events | 2.714 | 2.466 | 0.248 | 0.2543 |
| Loss of social connections, social isolation | 3.825 | 3.212 | 0.614 | 0.0031** |
| Not being in my academic classes | 3.794 | 3.410 | 0.383 | 0.0615 |
| What my academic future will hold | 4.032 | 3.492 | 0.540 | 0.0077** |
| If I will be able to return to school in the fall because of financial reasons | 2.508 | 2.212 | 0.296 | 0.1306 |
| If I will be able to return to school in the fall because of public health reasons | 3.825 | 3.154 | 0.672 | 0.0011** |
| Connecting with my faculty for class related concerns | 3.762 | 3.093 | 0.669 | 0.0004** |
| Connecting with my faculty for mentorship related topics | 3.413 | 3.034 | 0.379 | 0.0363 |
| Not learning as well in an online classroom | 4.206 | 4.051 | 0.156 | 0.3805 |
| Falling behind in content material that we will build on in future semesters | 4.190 | 3.590 | 0.601 | 0.0012** |
| That my grades from on-line learning will be problematic | 3.587 | 3.492 | 0.096 | 0.6492 |
| Connecting with classmates to collaborate on assignments | 4.111 | 3.407 | 0.704 | 0.0001** |

Note: * and ** indicate significant ($p < 0.05$) and highly significant ($p < 0.01$) differences between mean scores from women and men, respectively.

Differences across Time

Next, survey data were examined longitudinally to ascertain changes in students’ stress between the summer and fall 2020 survey time points. The summer survey was administered in mid-June, roughly a month after students completed the spring semester which was delivered remotely

from March onwards. At the time of the summer survey, neither students nor faculty knew how the fall semester would be delivered. The university was still in the early stages of planning for another semester impacted by the ongoing pandemic. When the survey was administered it was unknown whether the university would offer remote, hybrid, or in-person classes in the fall.

Table 4. Mean scores from women’s responses to COVID-19 screener questions at the summer and fall survey time points, including difference (delta) and p-value from t-tests.

| Question: Because of COVID-19 related events and changes, I have felt increased stress about: (1 = strongly disagree, 2 = somewhat disagree, 3 = neither agree nor disagree, 4 = somewhat agree, 5 = strongly agree) | Summer mean | Fall mean | Delta: mean fall - summer | p-value |
|--|--------------------|------------------|----------------------------------|----------------|
| Food running out or being unavailable | 2.226 | 2.031 | -0.195 | 0.5038 |
| Losing a job or decrease in family income | 3.677 | 3.156 | -0.521 | 0.1061 |
| Housing or utilities | 2.742 | 2.281 | -0.461 | 0.1674 |
| Loss of or limited childcare | 1.613 | 1.813 | 0.200 | 0.4924 |
| Taking care of children, including those who are normally in school | 2.194 | 1.938 | -0.256 | 0.4869 |
| Tension or conflict between household members | 3.968 | 3.000 | -0.968 | 0.0019** |
| Physical health concerns for me or a family member | 3.677 | 3.688 | 0.010 | 0.9769 |
| Increased anxiety or depression | 3.903 | 3.781 | -0.122 | 0.6887 |
| Reminders of past stressful/traumatic events | 2.742 | 2.688 | -0.054 | 0.8805 |
| Loss of social connections, social isolation | 4.194 | 3.469 | -0.725 | 0.0140* |
| Not being in my academic classes | 4.194 | 3.406 | -0.787 | 0.0101* |
| What my academic future will hold | 3.968 | 4.094 | 0.126 | 0.6781 |
| If I will be able to return to school in the fall because of financial reasons | 2.774 | 2.250 | -0.524 | 0.0909 |
| If I will be able to return to school in the fall because of public health reasons | 4.000 | 3.656 | -0.344 | 0.2638 |
| Connecting with my faculty for class related concerns | 3.935 | 3.594 | -0.342 | 0.2398 |
| Connecting with my faculty for mentorship related topics | 3.484 | 3.344 | -0.140 | 0.6431 |
| Not learning as well in an online classroom | 4.355 | 4.063 | -0.292 | 0.2995 |
| Falling behind in content material that we will build on in future semesters | 4.226 | 4.156 | -0.070 | 0.7941 |
| That my grades from on-line learning will be problematic | 3.677 | 3.500 | -0.177 | 0.6349 |
| Connecting with classmates to collaborate on assignments | 4.452 | 3.781 | -0.670 | 0.0060** |

Note: * and ** indicate significant ($p < 0.05$) and highly significant ($p < 0.01$) differences between mean scores from summer and fall survey time points, respectively.

The fall survey was administered in late-September/early-October, nearly six weeks into the fall semester. The university welcomed students back to campus for primarily in-person classes in late August. Some faculty and students were given medical accommodations to teach and learn fully online, but most courses in the engineering program were delivered in-person. Due to social distancing requirements, many classrooms were not large enough to seat the full course roster

such that some students took turns watching simulcasts of their instructors from “overflow” rooms. At the time of the fall survey, students had a solid understanding of the logistics and framework of the adjusted learning format, which is to say the list of uncertainties from the summer had shortened.

Table 5. Mean scores from men’s responses to COVID-19 screener questions at the summer and fall survey time points, including difference (delta) and p-value from t-tests.

| Question: Because of COVID-19 related events and changes, I have felt increased stress about: (1 = strongly disagree, 2 = somewhat disagree, 3 = neither agree nor disagree, 4 = somewhat agree, 5 = strongly agree) | Summer mean | Fall mean | Delta: mean fall - summer | p-value |
|--|--------------------|------------------|----------------------------------|----------------|
| Food running out or being unavailable | 2.000 | 1.838 | -0.162 | 0.4601 |
| Losing a job or decrease in family income | 2.940 | 2.809 | -0.131 | 0.6220 |
| Housing or utilities | 2.260 | 2.309 | 0.049 | 0.8422 |
| Loss of or limited childcare | 1.680 | 1.731 | 0.051 | 0.7902 |
| Taking care of children, including those who are normally in school | 1.820 | 1.809 | -0.011 | 0.9562 |
| Tension or conflict between household members | 2.860 | 2.412 | -0.448 | 0.0795 |
| Physical health concerns for me or a family member | 3.080 | 3.221 | 0.141 | 0.6063 |
| Increased anxiety or depression | 3.080 | 3.059 | -0.021 | 0.9395 |
| Reminders of past stressful/traumatic events | 2.560 | 2.397 | -0.163 | 0.5272 |
| Loss of social connections, social isolation | 3.320 | 3.132 | -0.188 | 0.4667 |
| Not being in my academic classes | 3.540 | 3.313 | -0.227 | 0.3679 |
| What my academic future will hold | 3.500 | 3.485 | -0.015 | 0.9530 |
| If I will be able to return to school in the fall because of financial reasons | 2.080 | 2.309 | 0.229 | 0.3317 |
| If I will be able to return to school in the fall because of public health reasons | 2.959 | 3.294 | 0.335 | 0.1823 |
| Connecting with my faculty for class related concerns | 3.180 | 3.029 | -0.151 | 0.5023 |
| Connecting with my faculty for mentorship related topics | 3.080 | 3.000 | -0.080 | 0.7061 |
| Not learning as well in an online classroom | 4.160 | 3.971 | -0.189 | 0.3773 |
| Falling behind in content material that we will build on in future semesters | 3.640 | 3.552 | -0.088 | 0.7050 |
| That my grades from on-line learning will be problematic | 3.580 | 3.426 | -0.154 | 0.5218 |
| Connecting with classmates to collaborate on assignments | 3.660 | 3.221 | -0.439 | 0.0475* |

Note: * and ** indicate significant ($p < 0.05$) and highly significant ($p < 0.01$) differences between mean scores from summer and fall survey time points, respectively.

The women’s mean responses to the COVID-19 screener questions are shown in Table 4, from the summer and fall surveys. Most of the differences in mean scores between the fall and summer are negative, indicating that stress decreased from summer to fall. In the cases where the difference rose, t-tests showed that the change was not statistically significant. Overall, four of the items were statistically different between survey time points, two in a highly significant way ($p < 0.01$), indicated by asterisks in Table 4. The most significant decreases in stress were found

from responses to “tension or conflict between household members” and “connecting with classmates to collaborate on assignments.”

Responses from the men were also analyzed longitudinally. The mean scores from the summer and fall survey time points are provided in Table 5. The change in mean scores between summer and fall are mostly negative, though not uniformly so. Only one mean score changed in a statistically significant way over time in the men’s responses, “Connecting with classmates to collaborate on assignments.” Interestingly, this item showed significant longitudinal differences for both men and women. The mean score for this item significantly decreased ($p < 0.05$) for men, while it had a highly significant decrease for women over time ($p < 0.01$).

Discussion

A cross-sectional analysis of responses to twenty COVID screener questions highlighted significant differences between men and women in the engineering program at our liberal arts university. Across all twenty questions, women reported higher feelings of stress due to COVID-19, and in half of those instances the increased stress was found to be statistically significant. The items in which women reported greater feelings of stress compared to their male peers spanned themes of home life, family, physical health, mental health, and academics. This study’s finding of heightened stress, across a range of themes and topics, experienced by women, as compared to men, is consistent with the literature.

First, this work found that women reported significantly higher feelings of anxiety or depression, as well as stress over loss of social connections, as indicated by responses to two screener questions. This observation matches reports of increased rates anxiety and depression among women, LGBTQ+ students, and racially minoritized populations due to the ongoing pandemic [4]. Moreover, a disproportionate amount of housework—including caregiving and housekeeping—has fallen on the shoulders of women [5] [6] [7]. It is not surprising then that the women survey participants in this study also indicated increased feelings of stress over issues relating to home life, as compared to their male peers. Furthermore, it was observed that women were more stressed than the men in a variety of academically themed questions as well. For example, women survey participants showed highly significant ($p < 0.01$) increased stress about connecting with “faculty members for class related concerns” and “classmates to collaborate on assignments,” compared to the men.

Though only two survey time points are included in this work, with plans to continue collecting data, a preliminary longitudinal analysis was carried out. Responses were compared from the summer and fall survey time points to gauge changing levels of stress in students as the pandemic continues. The summer time point captured students’ feelings of stress following the spring semester, whose second half was completed remotely. In the fall, our university re-opened for hybrid learning, such that responses from September may be impacted by students’ enhanced understanding of new learning modalities required in response to COVID-19.

In comparing the responses from women between June and September, it was observed that most mean scores did not change significantly across time. Two of the twenty screener items returned significant ($p < 0.05$) decreases in mean scores between the summer and fall, while another two items showed highly significant ($p < 0.01$) decreases over time. Stress over social connections and the ability to be in academic classes decreased significantly, while concerns about household conflicts and connecting with classmates to collaborate on work decreased in a highly significant way.

Men's responses to the COVID screener questions yielded only one observed significant change ($p < 0.05$) over time. It was observed that men's stress about "connecting with classmates to collaborate on assignments" significantly decreased over time, while for women it decreased with high statistical significance.

These decreases in stress over time are perhaps not surprising. The summer survey captured students' responses after completing the semester with remote learning, which was brought on suddenly. Furthermore, the summer survey was administered before decisions or announcements had been made about plans for the fall semester. The second survey point captured students' feelings a month into the fall semester. Therefore, it is likely that the observed decreases in stress are a reflection of students' better understanding of the new learning environment, and perhaps adaptation to the new modalities of learning. That is, the numerous unknowns about the future of their education led to heightened stress in the summer. These sources of stress became less pronounced for women across themes of home life, personal relationships and academics as time went on. However, men's changing stress levels only decreased for one academically themed question – which is likely a reflection of lower levels of anxiety over the other survey items to begin with.

Conclusions and Future Work

Responses to twenty COVID screener questions administered to undergraduate engineering majors at a liberal arts university in the summer and fall of 2020 were analyzed to explore both cross-sectional differences along gender lines as well as longitudinal changes during the ongoing pandemic. These results build on survey responses from a larger continuing study designed to enhance the recruitment and retention of women to undergraduate engineering programs through a better understanding of risk and resilience. It was observed that women are experiencing higher levels of stress across a range of themes, as compared to their male peers, due to the ongoing pandemic. Moreover, women's stress levels decreased significantly over time on four of the twenty screener questions, while the same was true of men on only one item.

Results provide valuable insight into the differential effects of the COVID-19 pandemic on the experiences of women and men students in an undergraduate engineering program. These differential experiences of stress, anxiety, and worry related to the pandemic appear to be consistent with the experiences of undergraduate students across the country. Such insights into

these differences can help educators provide better support to all students throughout the continued pandemic and its aftereffects, which remain unknown. Ultimately, this support may help recruit and retain a diverse population of engineering students.

Better support for engineering students, particularly marginalized students, during this time can include interventions that broadly fall into two categories: those that can be done by educators, and those that can be done on a college or university level. As educators, we are the front lines of interactions with students in our classrooms and in advising capacities. We can strive to better monitor individual students' well-being or changes to their well-being by noting changes in performance, engagement, and attendance. During these unprecedented times, we can also aim to be more sympathetic to the difficult experiences that students are having in the classroom and in their personal lives, and incorporate further flexibility into our curriculum. Things such as communicating care for the students, asking how students are doing, and having students do more reflections on their learning can improve our understanding of student well-being and our curriculum design. Literature also suggests that underrepresented students benefit from these kinds of check-ins [2] [4] [7].

On the university level, expanded counseling services during this time is an important intervention to help students manage the stress and anxiety of this pandemic. Educators can help bridge the gap between students and services and destigmatize counseling by discussing well-being with their students. Finally, frequent and transparent communication between the university and students may help to alleviate some of the anxiety and worry students feel when wondering what impacts the pandemic will have on their college experiences.

This work is part of a larger study assessing engineering student risk and resiliency in a small undergraduate engineering program at a liberal arts university in the northeastern US. The study has collected survey data each semester since the fall of 2018 and will continue to collect student responses for the foreseeable future. This study will ultimately allow us to compare engineering students' risk, resiliency and other mental health indicators from before COVID, throughout the pandemic, and hopefully into a post-COVID future. The COVID screener questions will be analyzed in conjunction with other instruments in the survey (e.g. those measuring engineering self-efficacy) to ultimately improve recruitment and retention of students in engineering programs, with a particular focus on increasing the participation rates of underrepresented populations.

References

- [1] M. Park, J. Park, K. Jackson and G. Vanhoy, "Online Engineering Education Under COVID-19 Pandemic Environment," *International Journal of Multidisciplinary Perspectives in Higher Education*, vol. 5, no. 1, pp. 160-166, 2020.
- [2] B. Means and J. Neisler, "Suddenly online: a national survey of undergraduates during the COVID-19 pandemic," Digital Promise, San Mateo, CA, 2020.
- [3] M. Adnan and K. Anwar, "Online Learning Amid the COVID-19 Pandemic: Students' Perspectives," *Journal of Pedagogical Sociology and Psychology*, vol. 2, no. 1, 2020.
- [4] I. Chirikov, K. Soria, B. Horgos and D. Jones-White, "Undergraduate and Graduate Students' Mental Health During the COVID-19 Pandemic," SERU Consortium Reports, University of California Berkley, 2020.
- [5] J. Malisch, B. Harris, S. Sherrer, K. Lewis, S. Shepherd, P. MacCarthy, J. Spott, E. Karam, N. Moustaid-Moussa, J. Calarco, L. Ramalingam, A. Taller, J. Canas-Carrell, K. Ardon-Dryer, D. Weiser, X. Bernal and J. Deitloff, "Opinion: In the wake of COVID-19, academia needs new solutions to ensure gender equity," *Proceedings of the National Academy of Sciences*, vol. 117, no. 27, pp. 15378-15381, 2020.
- [6] K. MacArthur, M. Cox, C. Egan and L. Komer, "Pre-existing Social Conditions: A Call to Prevent the Perpetuation of Gender Inequities in Research Production during COVID-19," *International Journal of Medical Students*, vol. 8, no. 3, pp. 217-219, 2020.
- [7] L. Gelles, S. Lord, G. Hopple, D. Chen and J. Mejia, "Compassionate Flexibility and Self-Discipline: Student Adaptation to Emergency Remote Teaching in an Integrated Engineering Energy Course during COVID-19," *Education Sciences*, vol. 10, no. 11, p. 304, 2020.
- [8] R. M. Marra, K. A. Rodgers, D. Shen and B. Bogue, "Women engineering students and self-efficacy: A multi-year, multi-institution study of women engineering student self-efficacy," *Journal of Engineering Education*, vol. 98, no. 1, pp. 27-38, 2009.
- [9] Q. A. Blanco, M. Carlota, A. Nasibog, B. Rodriguez, X. V. E. Salana and F. Gagani, "Probing on the Relationship between Students' Self-Confidence and Self-Efficacy while engaging in Online Learning amidst COVID-19," *Journal La Edusci*, vol. 1, no. 4, pp. 16-25, 2020.
- [10] J. Heo and S. Han, "Effects of motivation, academic stress and age in predicting self-directed learning readiness (SDLR): Focuses on online college students," *Education and Information Technologies*, vol. 23, no. 1, pp. 61-71, 2018.

- [11] N. Ramo, E. Hald and A. Huang-Saad, "Synchronous vs. asynchronous vs. blended remote delivery of introduction to biomechanics course," *Biomechanical Engineering Education*, pp. 1-6, 2020.
- [12] P. Muljana and T. Luo, "Factors contributing to student retention in online learning and recommended strategies for improvement: A systematic literature review," *Journal of Information Technology Education: Research*, vol. 18, pp. 19-57, 2019.
- [13] "AWE: Assessing Women and Men in Engineering," [Online]. Available: <http://aweonline.org/efficacy.html> . [Accessed June 23 2020].
- [14] "Youth Risk Behavior Surveillance System (YRBSS)," Center of Disease Control and Prevention, [Online]. Available: <https://www.cdc.gov/healthyyouth/data/yrbs/index.htm>. [Accessed 23 June 2020].
- [15] "Global Appraisal of Individual Needs -- Short Screener (GAIN-SS)," Chesnut Health Systems, [Online]. Available: <https://gaincc.org/instruments/> . [Accessed June 23 2020].
- [16] C. R. Snyder, L. Irving and J. Anderson, "Hope and health: Measuring the will and the ways," in *Handbook of social and clinical psychology: The health perspective*, Elmsford, NY, Pergamon Press, pp. 285-305.
- [17] A. Huth-Bocks, "COVID-19 Family Stress Screener," 2020. [Online]. Available: <https://docs.google.com/document/d/1xBFE0xn40EGF0og1JuBIOI7LLG1bLhtifPKbBc1ImZY/edit> . [Accessed 3 January 2020].