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Challenges of Remote Learning and Mentoring among Engineering Students and Faculty during the COVID-19 Pandemic

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Abstract

The pandemic of coronavirus disease 2019 (COVID-19) has severely affected the higher education system since Spring 2020. During the periods of school closures and limited in-person activities, engineering students and faculty experienced challenges in remote learning and mentoring activities. Funded by the National Science Foundation (NSF), this study surveyed 668 faculty and 3,385 undergraduate/graduate students in engineering from 94 institutions in 36 states across the country. Our findings indicated that several faculty and student subgroups were disproportionately negatively affected by the ongoing COVID-19 pandemic. Specifically, women engineering faculty and students encountered more challenges in transitioning to remote teaching and learning. Students with disabilities and those whose households experienced a loss of income during the COVID-19 pandemic faced more remote learning challenges, perceived less instrumental mentoring support, and were more likely to delay their graduate dates. Our structural equation modeling results showed that mentoring support could mitigate remote learning challenges and academic disruption for engineering students. The study underscores the importance of mentoring support during the crisis of a pandemic.

Introduction

The pandemic of coronavirus disease 2019 (COVID-19) has severely affected the higher education system since Spring 2020. In engineering fields, the outbreak disrupted faculty and students' daily school routine, which typically includes in-person classes, laboratory research, and mentoring activities. Funded by the National Science Foundation (DGE-2031069; DGE-2051263), this research project investigated the life and educational challenges faculty and students in engineering fields encountered during the pandemic, and examined how mentoring activities supported students' academic, career, and mental health outcomes.

We appreciate the invitation and opportunity to disseminate the findings at the NSF Grantees' Poster Session. In the presentation, we plan to share our findings regarding the challenges in remote learning and mentoring activities among engineering students and faculty members during the COVID-19 outbreak in Spring 2020. Building on our prior studies [1]–[6] and a well-established mentoring input-process-output model [7], [8], we will also present how the mentoring support could mitigate engineering students' remote learning challenges and academic disruption in the crisis of a pandemic.

Methods

Data/Sample

The data were collected through online surveys for faculty and students on June 3-22, 2020. Student survey invitations were emailed to the undergraduate and graduate students through deans/associate deans in engineering colleges across the country. The faculty members received the invitation directly through their email. Informed consents of participants were obtained electronically prior to gathering the survey data. The final analytic sample comprised 668 faculty and 3,385 undergraduate/graduate students in engineering from 94 institutions in 36 states.

Measures

The faculty survey included measures on technological challenges in transitioning to remote learning, challenges in adapting course design to remote learning, mentoring interaction frequency during the pandemic, and background characteristics. Technological challenges in transitioning to remote learning consist of 8 binary indicators (yes=1, no=0) [9]. Challenges in adapting course design to remote learning are measured by 7 binary indicators (yes=1, no=0) [9]. Mentoring interaction frequency during the pandemic includes 5 modes (i.e., in-person meeting, video conferencing, email, phone, and social media). Each mode is measured through a 5-Likert scale (much few hours = -2, fewer hours = -1, about the same hours = 0, more hours = 1, and much more hours = 2). Background characteristics include gender, race/ethnicity, and the academic rank for the current position. The detailed items and descriptive results are shown in Table 1.

Table 1. Descriptive results for engineering faculty data (N=668).

	M	SD	Min	Max
Technological Challenges in Transitioning to Remote Learning				
• Student discomfort or lack of familiarity with required technologies or applications	0.50	0.50	0	1
• My own discomfort or lack of familiarity with required technologies or applications	0.34	0.47	0	1
• My access to reliable communication software/tools (e.g., Zoom, Skype, Google)	0.09	0.29	0	1
• My access to reliable internet/service	0.32	0.47	0	1
• My access to a reliable digital device (e.g., laptop, mobile device)	0.10	0.30	0	1
• My access to specialized software (e.g., Adobe products, statistical packages)	0.18	0.39	0	1

• Adequate digital replacements for face-to-face collaboration tools (e.g., whiteboards)	0.58	0.49	0	1
• My access to library resources	0.12	0.33	0	1
Challenges in Adapting Course Design to Remote Learning				
• I am not familiar or comfortable with online applications/tools	0.14	0.35	0	1
• I have limited knowledge of options for online course delivery	0.24	0.43	0	1
• I have limited personal time or energy to effectively adapt	0.38	0.48	0	1
• My personal preference is for face-to-face learning	0.62	0.49	0	1
• Course lessons or activities haven't translated well to a remote environment	0.34	0.48	0	1
• I am uncertain about how to best assess student learning in this environment	0.51	0.50	0	1
• Students have not been adequately available/responsive	0.36	0.48	0	1
Mentoring Interaction Frequency during the Pandemic				
• In-person meeting	-1.50	0.92	-2	2
• Video conferencing	1.61	0.72	-2	2
• Email	0.78	0.78	-2	2
• Phone	0.25	0.77	-2	2
• Social media	0.06	0.60	-2	2
Background Characteristics				
• Men	0.65	0.48	0	1
• Women	0.31	0.46	0	1
• Other gender	0.03	0.18	0	1
• Black/Hispanic/Native American	0.11	0.32	0	1
• Other racial groups (e.g., White, Asian, etc.)	0.89	0.32	0	1
• Assistant professor	0.31	0.46	0	1
• Associate professor	0.26	0.44	0	1
• Full professor	0.40	0.49	0	1
• Other faculty	0.03	0.17	0	1

Note. M = mean; SD = standard deviation; Min. = minimum; Max. = maximum.

The student survey included measures on remote learning challenges, perceived instrumental support, perceived psychosocial support, academic disruption, and background characteristics. Remote learning challenges consist of 8 binary indicators (yes=1, no=0) [9]. Both perceived instrumental support and perceived psychosocial support are measured by 4 indicators through a 5-Likert scale ranging from -2 (much less support) to 2 much (much more support) [10]–[12]. For academic disruption, students were asked to report whether the COVID-19 outbreak delayed their expected graduate dates and, if so, to estimate the expected total number of delayed months. Background characteristics include their degree, disability status, household member experiencing a loss of income during the pandemic, gender, race/ethnicity, and citizenship status.

The items and descriptive statistics are provided in Table 2. Other information about the student survey items can also refer to our previous study [1].

Table 2. Descriptive results for engineering student data (N=3,385).

	M	SD	Min	Max
Remote Learning Challenges				
• Finding time to participate in synchronous classes (e.g., live-streaming lectures or video conferencing at a set time)	0.35	0.48	0	1
• Unclear expectations around course/assignment requirements	0.55	0.50	0	1
• Competing class meetings and schedules	0.23	0.42	0	1
• Personal preference for face-to-face learning	0.66	0.47	0	1
• Course lessons or activities that haven't translated well to a remote environment	0.63	0.48	0	1
• Difficulty focusing or paying attention to remote instruction or activities	0.71	0.45	0	1
• Instructor availability/responsiveness	0.28	0.45	0	1
• Personal motivation/desire to complete coursework	0.67	0.47	0	1
Perceived Instrumental Support				
• Finish my assignments/projects	-0.11	0.84	-2	2
• Improve my writing skills	-0.23	0.77	-2	2
• Prepare for my presentations	-0.23	0.80	-2	2
• Explore my career options	-0.15	0.87	-2	2
Perceived Psychosocial Support				
• Discuss my concerns about academic projects	0.02	0.86	-2	2
• Pursue my learning interests	-0.04	0.80	-2	2
• Work toward my career goals	-0.02	0.83	-2	2
• Talk about my anxiety in career outlook	-0.06	0.88	-2	2
Academic Disruption				
• Graduation date delayed (Yes/No)	0.11	0.31	0	1
• Graduation date delayed (Months)	0.58	1.99	0	14
Background Characteristics				
• Bachelor	0.76	0.43	0	1
• Master	0.16	0.36	0	1
• Doctorate	0.08	0.27	0	1
• Disabled	0.09	0.28	0	1
• Non-disabled	0.56	0.50	0	1
• Disability status – did not report	0.35	0.48	0	1
• Household member experienced a loss of income	0.29	0.46	0	1
• Household member did not experience a loss of income	0.35	0.48	0	1
• Loss of income – did not report	0.36	0.48	0	1

• Women	0.29	0.45	0	1
• Men	0.35	0.48	0	1
• Other gender	0.36	0.48	0	1
• Black/Hispanic/Native American	0.11	0.32	0	1
• Other racial groups (e.g., White, Asian, etc.)	0.55	0.50	0	1
• Race/Ethnicity – did not report	0.34	0.47	0	1
• Citizen/permanent residents	0.56	0.50	0	1
• International students	0.08	0.28	0	1
• Citizenship status – did not report	0.36	0.48	0	1

Note. M = mean; SD = standard deviation; Min. = minimum; Max. = maximum.

Analytic Strategy

We employed Structural Equation modeling (SEM) to test the relationships among latent factors (technological challenges in transitioning to remote learning, challenges in adapting course design to remote learning, remote learning challenges, perceived instrumental support, perceived psychosocial support), the observed variable (academic disruption), and background characteristics. SEM can model the interrelationships among variables and handle the measurement errors of the latent factors simultaneously. To model the binary variables (academic disruption and binary indicators for technological challenges in transitioning to remote learning, challenges in adapting course design to remote learning, and remote learning challenges), we applied the Weighted Least Squares Mean and Variance-Adjusted (WLSMV) estimator with a Probit link. For the continuous variables (perceived instrumental support and perceived psychosocial support), a Maximum Likelihood (ML) estimator was implemented. All the SEM models were performed in *Mplus 8.6* [13].

Results

Remote Learning Challenges during the COVID-19 Pandemic

For engineering faculty, we found that women faculty members experienced more technological challenges in transitioning to remote learning ($b=.128$, $p< .05$) and more challenges in adapting course design to remote learning ($b=.251$, $p<.05$) than their men colleagues. No significant differences were found within racial groups (racial minority vs. other groups) and academic ranks (assistant professor vs. full professor, associate professor vs. full professor, and other faculty vs. full professor).

For engineering students, undergraduate students encountered more challenges in remote learning than master's (b=-.203, p<.001) and doctoral students (b=-.340, p<.001). Students with disabilities faced more challenges in remote learning (b=.167, p<.001) than their non-disabled peers. Students whose households experienced a loss of income during the COVID-19 pandemic encountered more challenges in remote learning (b=.107, p<.001) than their counterparts. Similar to faculty experiences, women experienced more challenges in remote learning (b=.192, p<.001) than men. Surprisingly, underrepresented minority students (Black, Hispanic, and Native Americans; b=-.106, p<.01) and international students (b=-.328, p<.001) encountered fewer challenges in remote learning than their counterparts.

Mentoring challenges during the COVID-19 Pandemic

For engineering faculty, the mentoring interaction frequency through face-to-face during the COVID-19 outbreak showed a significant decrease (mean=-1.497, p<.001) than the frequency during the pre-pandemic. Despite that, we found there was a significant increase in mentoring interaction frequency via video conferencing (mean=1.608, p<.001), email (mean=.781, p<.001), phone (mean=.251, p<.001), and social media (mean=.063, p<.01).

For engineering students, their overall perception of instrumental and psychosocial mentoring support during the pandemic showed a decrease (Table 2). Taking a closer look at their background characteristics, we did not find any significant differences in the perception of psychosocial support. However, undergraduate students perceived less instrumental support than master's (b=.148, p<.01) and doctoral students (b=.232, p<.001). Students with disabilities perceived less instrumental support (b=-.090, p<.05) than non-disabled peers. Students whose households experienced a loss of income during the COVID-19 pandemic also perceived less instrumental support (b=-.107, p<.01) than their counterparts. No significant differences in perceived instrumental support were found within gender groups, racial groups, and citizenship statuses.

Academic disruption during the COVID-19 Pandemic

About 10.0% of our engineering student sample reported their expected graduation date was delayed due to the COVID-19 outbreak. Most of them indicated their graduation date was delayed by six months or less. Master's students (probit=.171, p<.001), doctoral students (probit=.320, p<.001), students with disabilities (probit=.132, p<.001), students whose household experienced a loss of income during the COVID-19 pandemic (probit=.107, p<.01), men (probit = .084, p<.05), and underrepresented minority students (probit=.091, p<.01) were more like to delay their graduation.

Relationships among Mentoring Support, Remote Learning Challenges, and Academic Disruption during the COVID-19 Pandemic

The SEM results (Figure 1) indicated that the perceptions of mentoring support during the COVID-19 outbreak showed a negative association with remote learning challenges and academic disruption, meaning that the higher level of mentoring support perception, the lower level of remote learning challenges and the less likelihood of academic disruption. The remote learning challenges only showed a marginally significant relationship with academic disruption. The insignificant relationship was not surprising because our previous descriptive analysis indicated that the reason for academic disruption during the pandemic could be not only academic related factors but also mental health issues, uncertain financial support, family responsibilities, and so on [6].

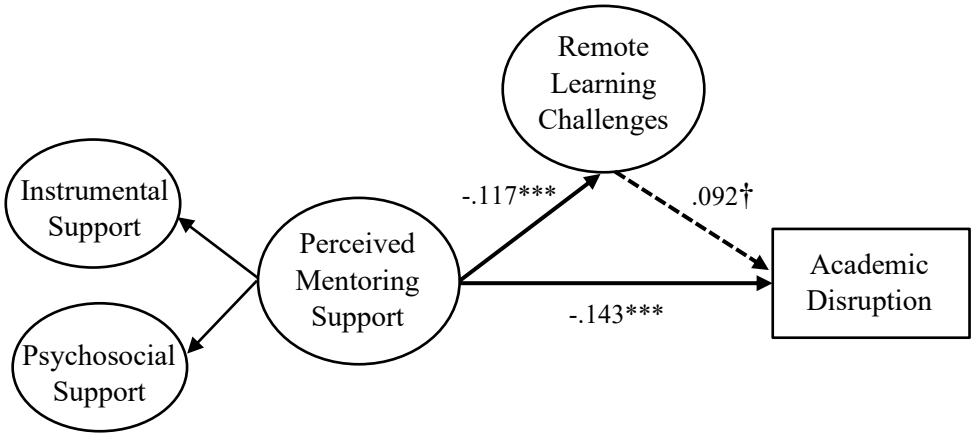

Figure 1. SEM results for the relationships between Mentoring Support, Remote Learning Challenges, and Academic Disruption during the COVID-19 Pandemic

Note. SEM = Structural Equation Modeling. Values = standardized path coefficients. Oval = Latent variable (constructed by a set of indicators to handle the measurement error issue). Rectangle = observed variable. Dashed paths are not statistically significant. Demographics for mentoring support, remote learning challenges, and academic disruption were controlled. Mentoring Support was measured by two latent factors (Instrumental Support and Psychosocial Support) by using a second order confirmatory factor analysis (CFA). Remote Learning Challenges was measured by a set of binary indicators by using a CFA. Academic Disruption is a binary observed outcome. N = 3,385 students. †p<.10 ***p<.001.

Overall, the model adequately fits the empirical data: Root Mean Square Error of Approximation (RMSEA) = .026; Comparative Fit Index (CFI) = .961; Standardized Root Mean Square Residual (SRMR) = .057 [14], [15]. Perceived mentoring support and other covariates (student background characteristics) can account for 29.3% of the variance in remote learning challenges. Perceived mentoring support, remote learning challenges, and other covariates (student background characteristics) can explain 19.3% of the variance in academic disruption.

Conclusion

This study investigated the challenges in remote learning and mentoring activities among engineering students and faculty members during the COVID-19 outbreak in Spring 2020. We found that women engineering faculty members experienced more technological challenges and course design difficulties in remote teaching. A number of engineering student groups (undergraduates, women, students with disabilities, students whose households experienced a loss of income during the COVID-19 pandemic, non-Black/Hispanic/Native Americans, and citizens/permanent residents) faced more remote learning challenges than their counterparts.

Mentoring activities were also affected by the months of lockdown in Spring 2020. The mentor-mentee activities significantly shifted from in-person to video conferencing, emailing, phone, and social media. Students' perceptions of instrumental support and psychosocial support from their mentor (faculty, staff, peers) showed decreases. Undergraduates, students with disabilities, and students whose households experienced a loss of income during the COVID-19 pandemic perceived less instrumental support than their peers.

About 10% of engineering students reported their graduation date would be delayed by the pandemic, especially for graduate students, students with disabilities, students whose households experienced a loss of income during the COVID-19 pandemic, men, and underrepresented minority students. Our modeling results suggested mentoring support could mitigate these academic challenges. The findings highlight the importance of mentoring support during a pandemic crisis.

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