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Electronic Mentoring During the COVID-19 Pandemic: Effects on Engineering Graduate Students' Academic, Career, and Mental Health Outcomes

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Electronic Mentoring during the COVID-19 Pandemic: Effects on Engineering Graduate Students' Academic, Career, and Mental Health Outcomes

Abstract

As the COVID-19 pandemic has significantly disrupted engineering graduate students' learning progress, electronic mentoring has become an emerging approach for faculty to support students. The present study investigated students' e-mentoring experience and academic, career, and mental health outcomes among 566 engineering graduate students from 44 institutions in 16 states. Descriptive results showed that face-to-face mentoring activities during the COVID-19 outbreak were mainly replaced by video conferencing and emailing. Our structural equation modeling (SEM) results indicated that e-mentoring inputs (i.e., e-mentoring attitude and individual development plan) and processes (i.e., e-mentoring frequency, perceived instrumental support, and perceived psychosocial support) are positively associated with mentoring satisfaction, which in turn positively predicts student academic, career, and mental health outcomes. The findings also revealed that mentoring experience, academic progress, career self-belief, and mental health of underrepresented groups—females, lower socioeconomic status (SES) students, and students with disabilities—were disproportionately negatively affected by the COVID-19 pandemic.

Introduction

As of late March 2020, in response to the Coronavirus Disease 2019 (COVID-19) pandemic, hundreds of colleges and universities in the United States (and across the globe) suspended face-to-face classes, closed campuses, and only allowed essential activities and core facilities to continue. The pandemic disrupted engineering graduate students' regular learning routines, which typically include in-person laboratory research and mentoring activities. As a result, engineering students during the COVID-19 pandemic may particularly experience challenges to their academic progress, career preparation, financial security, and physical/mental health [1]–[6].

During school closures, faculty were expected to continue mentoring and supporting their students through electronic or computer-mediated communication (CMC) technology. With the development and popularity of virtual communications, mobile messaging, and social media, faculty could provide 24/7 access for mentoring without spatial-temporal limitations [7]. It remains unclear whether e-mentoring—the process in which electronic media are used as the main channel of communication between mentor and mentee—can mitigate negative crisis impacts and promote positive outcomes for students during the COVID-19 pandemic.

Numerous meta-analytic reviews based on studies on face-to-face mentoring found that perceptions of mentoring relate to mentoring satisfaction, which in turn predict a wide range of mentee outcomes [8]–[11]. The limited number of empirical studies on e-mentoring suggests that mentees can learn and benefit from mentoring support via virtual or electronic interactions, even

without traditional face-to-face meetings or communication [12], [13]. However, prior e-mentoring studies are limited in their methodology as they are largely descriptive in nature, their samples tend to be small, only from a single institution, and not demographically diverse.

This study contributes to the literature on e-mentoring and pandemic impacts by investigating e-mentoring experience and student outcomes during the COVID-19 pandemic with a diverse sample of 566 engineering graduate students from 44 institutions in 16 states. Drawing on a well-established Mentoring Input-Process-Outcome (MIPO) model, derived from the literature on face-to-face mentoring literature [10], [14], this study formulates a conceptual model for empirically testing the interrelationships among e-mentoring experience and student academic, career, and mental health outcomes (Figure 1).

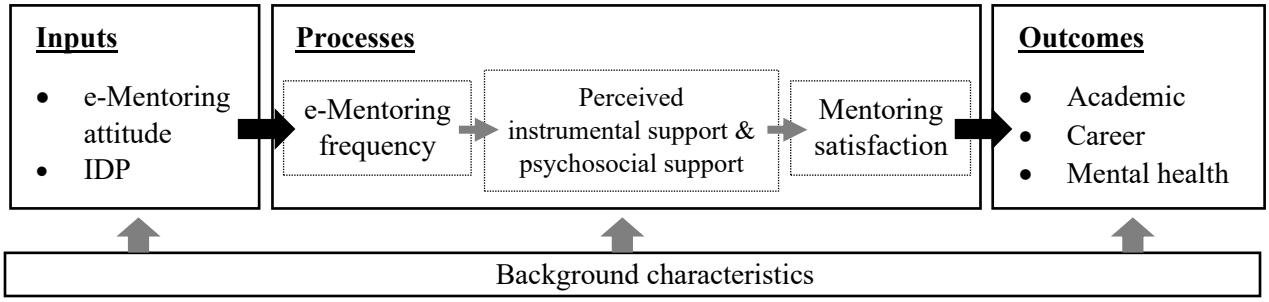

Figure 1. Conceptual model linking e-mentoring experience and student outcomes of engineering graduate students during the COVID-19 pandemic

The first central component of e-mentoring process is perceived instrumental support, referring to mentor behaviors that facilitate mentee goal attainment [15], [16]. The second key component is perceived psychosocial support, referring to mentor behaviors that promote mentee personal and emotional development [15], [17]. For a mentee to reap the benefits of mentoring, frequent interpersonal interaction with their mentor is needed [18], [19].

Given that shifting to e-mentoring is relatively new experience for students, their attitude towards e-mentoring could be an important input for the mentoring process. Additionally, the individual development plan (IDP) has been a commonly used mentoring tool to help mentees self-assess current skills and communicate with their mentor to develop an action plan to achieve their strategic goals [20]. Mentor and mentee will constantly revisit the IDP to track progress and refine the short- and long-term objectives. This process brings together mentor and mentee and establishes a long-term mentorship. In science, technology, engineering, mathematics, and medicine (STEMM) fields, the use of IDPs are strongly encouraged [20], [21], which may strengthen the relationship between engineering graduate students and their mentors. In sum, this model posits that the mentoring inputs are likely to affect mentoring processes, which in turn

influence mentees' outcomes. The mentees' background characteristics are functioning throughout the process.

Methods

Data/Sample

This study launched a 12-15 minute online survey using Qualtrics during June 3-22, 2020. Survey invitations were emailed to engineering graduate students via their deans and associate deans of engineering colleges across the country. Informed consent from participants was obtained prior to their participation. The final analytic sample consisted of 566 engineering graduate students from 44 institutions in 16 states. Among the survey respondents, 40.3% were females, 13.8% were underrepresented racial/ethnic minorities (URMs; Black/Hispanic/Native American), 33.2% reported their household experienced a loss of income during the COVID-19 pandemic, 12.0% were students with disabilities, 36.4% were international students, and 38.7% were doctoral students.

Measures

The survey collected an array of measures on student's e-mentoring experiences during the pandemic. In the mentoring section of the survey, students answered the questions in reference to the primary mentor with whom they learn/work most closely with on campus. Students indicated who their *primary mentor* was from the following options: academic advisor or thesis/dissertation chair, faculty member, staff member, peer (senior graduate student), or other. To investigate the *e-mentoring frequency*, we asked students to compare the changes in interaction frequency with their mentor via face-to face, video conferencing, email, phone, and social media, before and after the COVID-19 outbreak. The options include much few hours (-2), fewer hours (-1), about the same hours (0), more hours (1), and much more hours (2). *Perceived instrumental support* was measured by four questions [22]–[24], including: After the COVID19 outbreak, my primary mentor provided more/less support to help me (1) finish my assignments/projects; (2) improve my writing skills; (3) prepare for my presentations; (4) explore my career options. *Perceived psychosocial support* was also measured by four questions [22]–[24], including: After the COVID-19 outbreak, my primary mentor provided more/less support to encourage me to (1) discuss my concerns about academic projects; (2) pursue my learning interests; (3) work toward my career goals; (4) talk about my anxiety in career. The 5-point Likert scale for perceived instrument support and psychosocial support ranged from -2 (much less support) to 2 much (much more support). The Cronbach's alphas (reliability test results) for perceived instrumental support and perceived psychosocial support are .856 and .897, respectively.

Our survey also measured student's *e-mentoring attitude* by asking: Which communication approach is more effective? The options include face to face (FF) much more effective (-2), FF more effective (-1), both equally effective (0), e-communication (EC; e.g., email, phone, video conferencing, social media) more effective (1), and EC much more effective.

The Cronbach's alpha for the e-mentoring attitude measure is .902. *Mentoring satisfaction* was assessed with a single item (How satisfied were you with the support you received from your primary mentor during this past spring 2020 semester?) on a 9-point scale from 1 (extremely dissatisfied) to 9 (extremely satisfied). Given that *the use of Individual Development Plans (IDPs)* during the mentoring process is common in STEMM, we also asked students to report if they use the IDP with their primary mentor.

For student's *academic outcome*, we asked students to report whether the COVID-19 outbreak delayed their expected graduate dates and, if so, to estimate the expected total number of delayed months, including: 1-3 months, 4-6 months, 7-9 months, 10-12 months, and more than one year. In terms of the *career outcome*, we evaluated students' job search self-efficacy by asking three questions [25]: "Since the COVID-19 outbreak occurred, how confident have you become in finding (1) the job for which you are qualified? (2) a job in a company/institution that you prefer? (3) the job for which you are prepared?" The 5-point Likert scale was from -2 (much less confident) to 2 (much more confident). The Cronbach's alpha for these three job search self-efficacy items is .906. The measure for *mental health outcome*, which focused on symptoms of depression and anxiety, asked students if in the last 7 days they experienced, (1) feeling down, depressed, or hopeless; (2) having little interest or pleasure in doing things; (3) not being able to stop or control worrying; (4) feeling nervous, anxious, or on edge. The response options ranged from 1 (not at all) to 4 (nearly every day) [26]. The Cronbach's alpha of these four mental health items is .876.

Demographic information including gender, race/ethnicity, socioeconomic status (SES), disability status, citizenship status, age, and educational degree level was collected and treated as control variables in the statistical models. To measure student's SES, we employed the MacArthur Scale of Subjective Social Status [27], which is a scale from 1 (people who have the least money, least education, and worst jobs or no job) to 10 (people who have the most money, most education, and best jobs).

Analytic Strategy

Descriptive statistics and one-sample t-tests were first conducted to present the engineering graduate students' mentoring experiences and academic, career, and mental health outcomes during the COVID-19 pandemic. For each measure, we then tested differences in demographic backgrounds (i.e., gender, gender, race/ethnicity, SES, disability status, citizenship status, age, and educational degree level) by using Structural Equation Modeling (SEM) given that some measures (i.e., job search self-efficacy, mental health problems, perceived instrumental support, perceived psychosocial support, and e-mentoring attitudes) are latent factors constructed by a few sets of indicators. Finally, to examine our e-mentoring conceptual model (see Figure 1), we employed SEM to investigate the interrelationships among mentoring experience and student outcomes. All the SEM models were performed in *Mplus 8.5* [28]. Missing data ranged from zero to a high of 8% for mentoring satisfaction. We applied the full information maximum likelihood (FIML) approach to improve the estimation due to the missing data [29].

Results

Negative Impacts Due to the COVID-19 Pandemic

In June 2020, about one-fourth of our engineering graduate sample (24.7%) reported that their expected graduation date was delayed due to the COVID-19 outbreak (Figure 2). Most of these students estimated that their graduation date was delayed by six months or less. We also found that low-SES students and doctoral students were more likely to delay their graduation because of the pandemic.

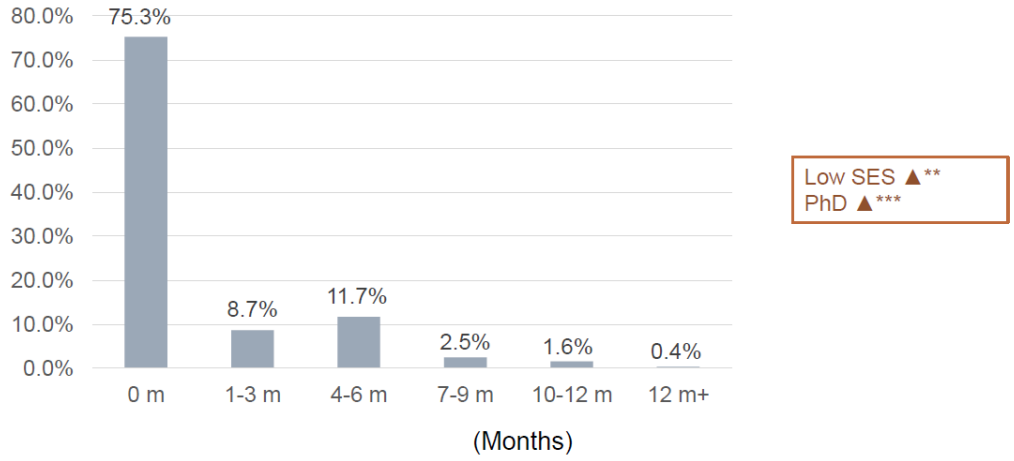

Figure 2. Delayed Graduation due to the COVID-19 Pandemic

In terms of job search self-efficacy (Figure 3), the one-sample t-test results showed that the means for all items are statistically different from 0 (The Same), meaning that, in general, engineering graduate students showed less confidence in their job search since the COVID-19 outbreak occurred. In particular, females, low-SES students, international students, and students with disabilities were less confident than their peers.

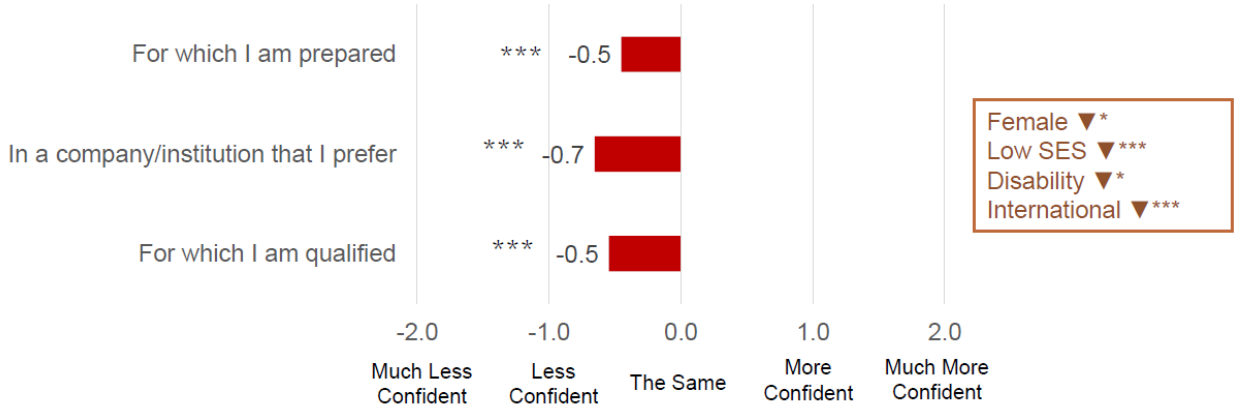

Figure 3. Job Search Self-Efficacy affected by the COVID 19 Pandemic

Note. The survey question is "Since the COVID-19 outbreak occurred, how confident have you become in finding a job…" *p<.05, **p<.01, ***p<.001.

Regarding mental health problems (Figure 4), engineering graduate students, on average, were bothered by these four issues about several days a week. Females, low-SES students, international students, and students with disabilities were more likely to experience mental health problems during the pandemic.

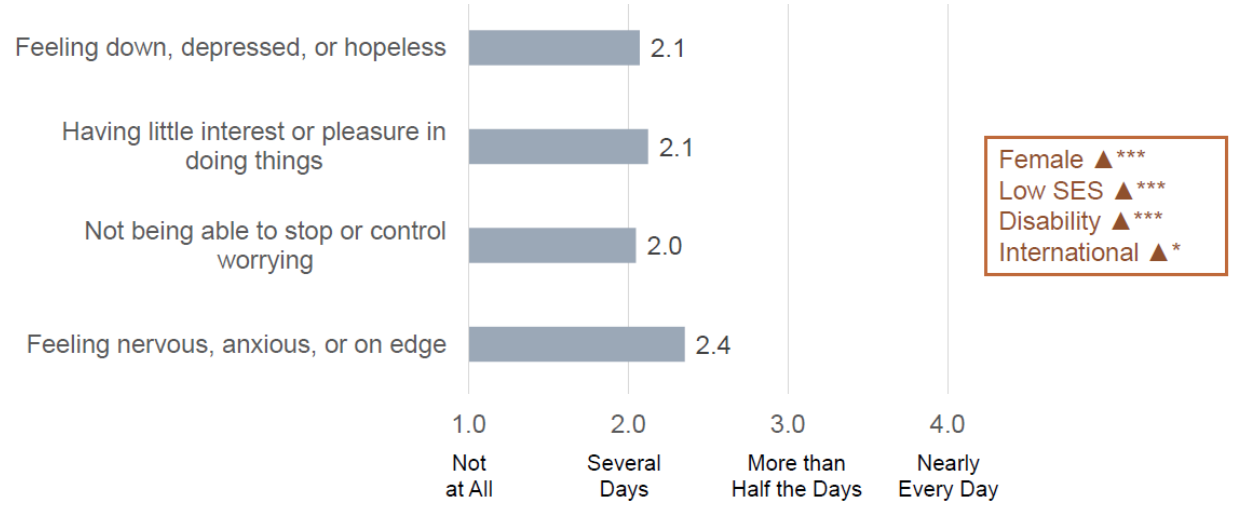

Figure 4. Mental Health Problems during the COVID-19 Pandemic

Note. The survey question is "Over the last 7 days, how often have you been bothered by the following problems?" *p<.05, **p<.01, ***p<.001.

e-Mentoring Experience during the COVID-19 Pandemic

The engineering graduate student sample of our study was primarily mentored by their advisor or thesis/dissertation chair (72%; see Figure 5). Mentorship was also provided by other faculty members (15%), staff members (2%), peer (6%), and other people (5%) on campus. About 30% of our sample used an individual development plan (IDP) with their mentor (Figure 6). However, master's students and students with disabilities were less likely to use the IDP.

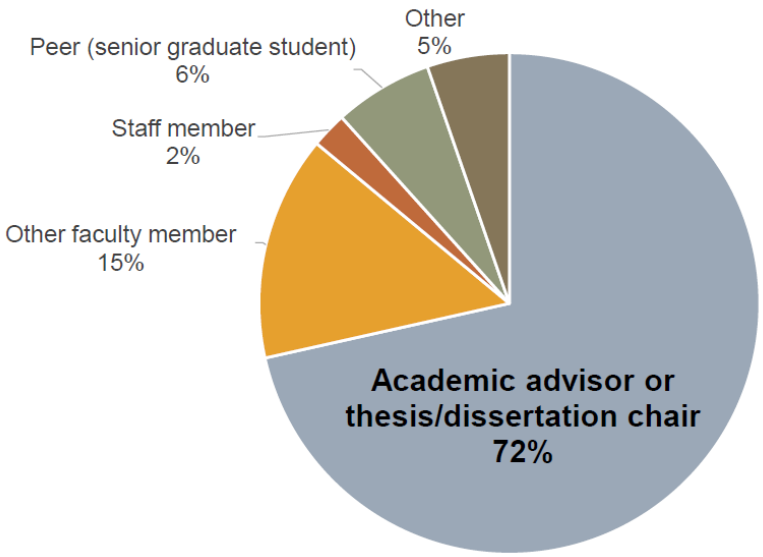

Figure 5. Primary Mentors on Campus

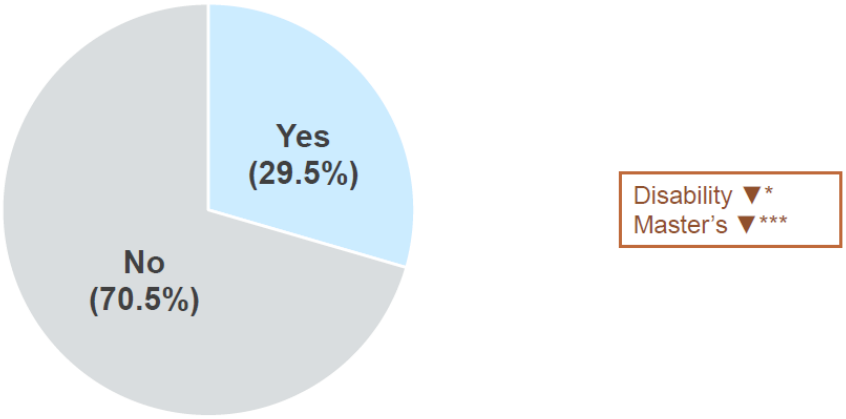

Figure 6. The use of IDPs

Based on the one-sample t-test results, mentoring interaction via different means showed significant changes in frequency during the pandemic (Figure 7). The interaction frequency through video conferencing and email showed a significant increase, while the frequency for other approaches, especially for face to face, significantly decreased during the crisis. At the same time, we found that master's students had fewer e-mentoring interactions (i.e., video conferencing, email, phone, and social media) than doctoral students.

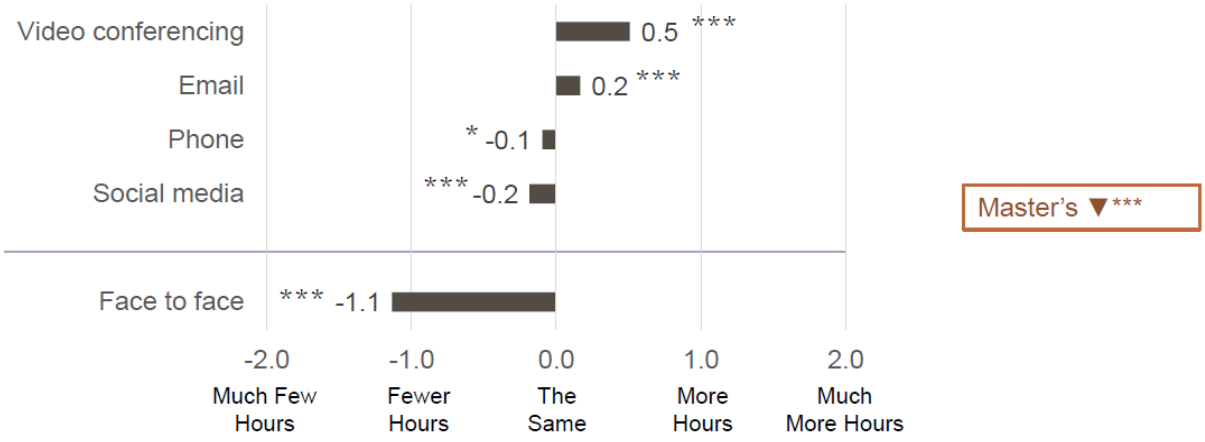

Figure 7. e-Mentoring Frequency during the COVID-19 Pandemic

Engineering graduate students self-assessed their perception of mentoring support during the pandemic. For instrumental support (Figure 8), the one-sample t-test results indicated students had less support for preparing for their presentations and exploring their career options. In terms of psychosocial support (Figure 9), the results revealed that students gained more support for discussing concerns about academic projects. For the rest of the mentoring activities listed in Figure 7 and 8, we did not find any significant changes during the outbreak. We further investigated students' attitude towards e-mentoring on the mentoring activities listed in Figure 10. In general, engineering graduate students, especially low-SES students, believed that mentoring through face-to-face interactions is more effective than mentoring through e-communication methods.

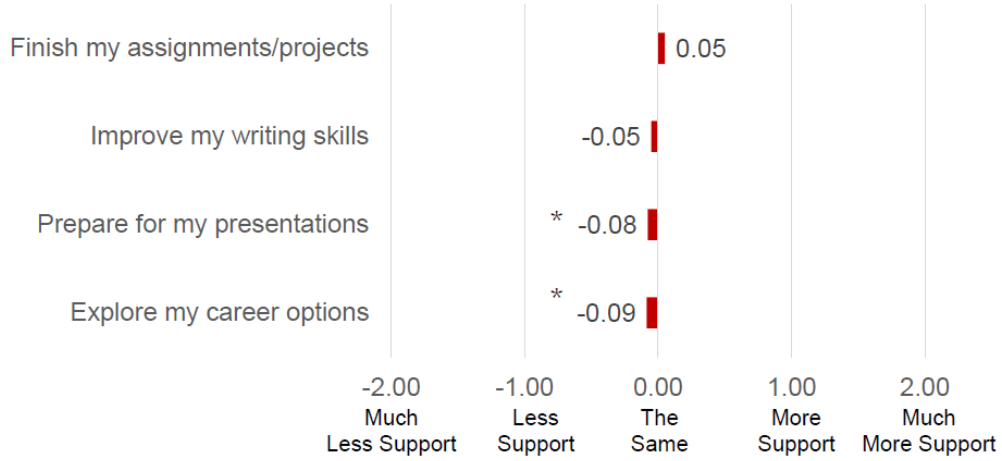

Figure 8. Perceived Instrumental Support during the COVID-19 Pandemic

Note. The survey question is "After the COVID-19 outbreak, my primary mentor provided more/less support to help me…"

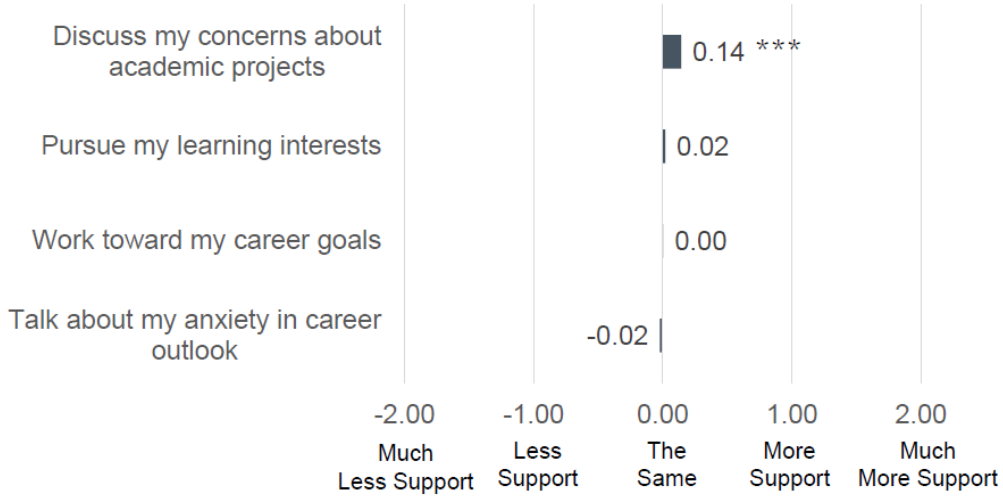

Figure 9. Perceived Psychosocial Support during the COVID-19 Pandemic

Note. The survey question is "After the COVID-19 outbreak, my primary mentor provided more/less support to encourage me to…"

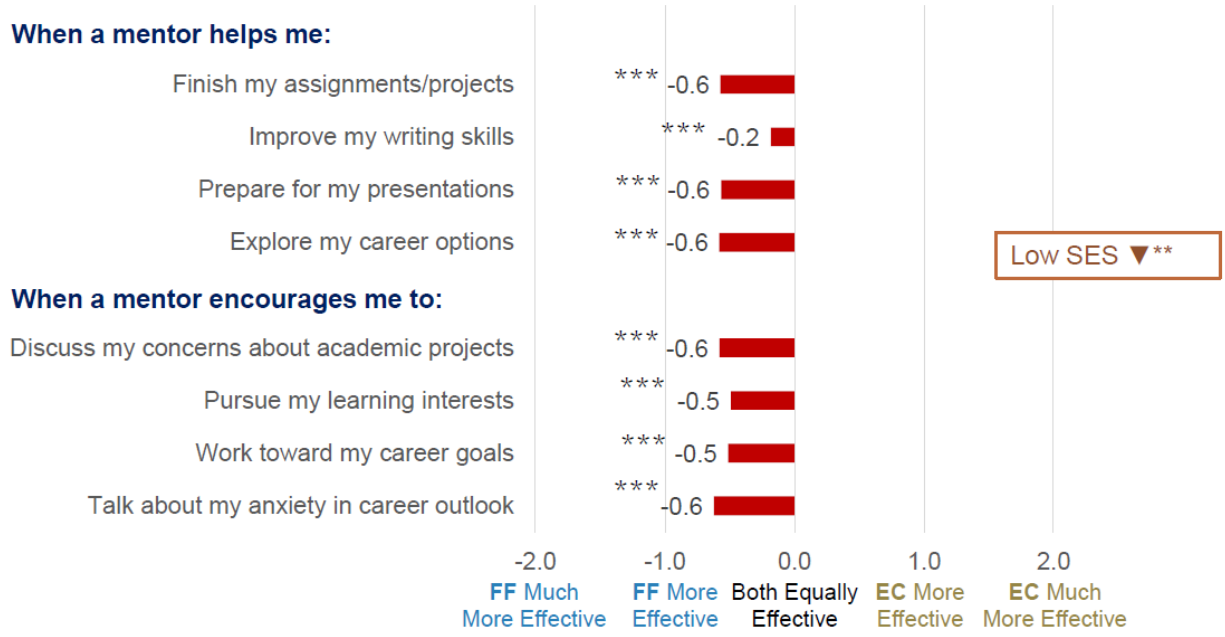

Figure 10. e-Mentoring Attitudes

Note. FF = face to face. EC = e-communication (e.g., email, phone, video conferencing, social media). The survey question is "For the following mentoring activities, which communication approach is more effective?"

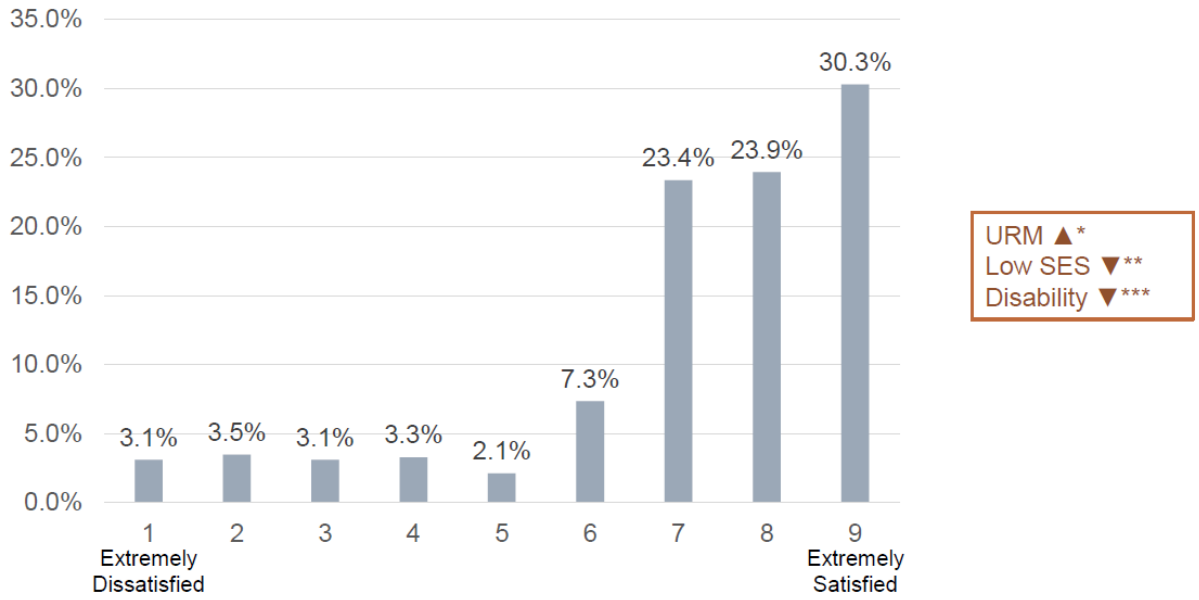

Figure 11. Mentoring Satisfaction during the Pandemic

Note. The survey question is "How satisfied were you with the support you received from your primary mentor during the pandemic?"

Overall, most engineering graduate students, especially URMs (Black/Hispanic/Native American), were satisfied with mentoring support during the pandemic (Figure 11). Nevertheless, low-SES students and students with disabilities reported lower levels of mentoring satisfaction than their high-SES counterparts.

How e-Mentoring Supports Engineering Graduate Students during the COVID-19 Pandemic

The SEM results showed that the conceptual model fits the empirical data adequately (RMSEA=.03; CFI=.95; SRMR=.07). The results (Figure 12) revealed that the e-mentoring interaction frequency was positively associated with the instrumental support and psychosocial support perceived by engineering graduate students. Both perceptions of instrumental support and psychosocial support were highly correlated with each other. Meanwhile, perceived mentoring support was positively related to mentoring satisfaction, which in turn positively predicted student outcomes. In particular, higher mentoring satisfaction was positively related to higher job search self-efficacy among students. Mentoring satisfaction was also associated with delayed graduation and mental health problems. We found that mentoring satisfaction mitigates mental health problems and lowers the likelihood of delaying graduation. As expected, we found that the correlation between job search self-efficacy and mental health problems was negative, whereas the correlation between delayed graduation and mental health problems was positive.

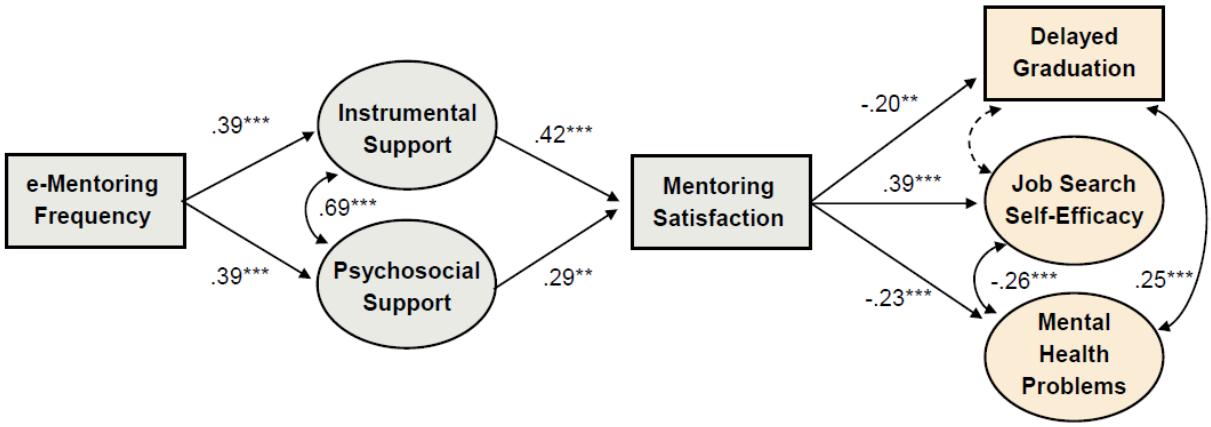

Figure 12. SEM Results for the Relationships between e-Mentoring Process and Student Outcomes during the COVID-19 Pandemic

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 were controlled. *p<.05, **p<.01, ***p<.001.

How e-Mentoring Attitude Relates to Mentoring Process and Satisfaction

Given the associations found among e-mentoring process, satisfaction, and student outcomes, we further examined whether and to what extent the e-mentoring attitude was related to the e-mentoring process and satisfaction. The SEM model also showed a good fit (RMSEA=.05; CFI=.93; SRMR=.05). The results (Figure 13) suggested e-mentoring attitudes positively predicted e-mentoring frequency. The relationships between frequency, mentoring support, and mentoring satisfaction remained significantly connected.

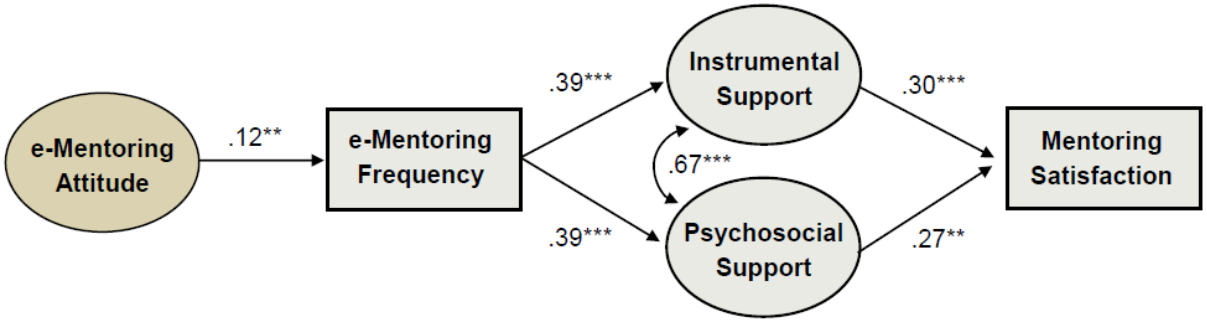

Figure 13. SEM Results for the Relationships between e-Mentoring Attitude and Mentoring Process during the COVID-19 Pandemic

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 were controlled. *p<.05, **p<.01, ***p<.001.

How the IDP Enhances the Mentoring Process and Satisfaction

The use of IDPs implied a well-connected relationship between mentor and mentee. Figure 14 shows the relationship between the use of IDPs, mentoring process, and mentoring satisfaction. The SEM model showed a good fit (RMSEA=.03; CFI=.97; SRMR=.07). The results revealed that students who used the IDP with their mentor showed a higher e-mentoring frequency than their counterparts. At the same time, higher e-mentoring frequency was associated with more mentoring support, which was also related to higher mentoring satisfaction during the COVID-19 outbreak.

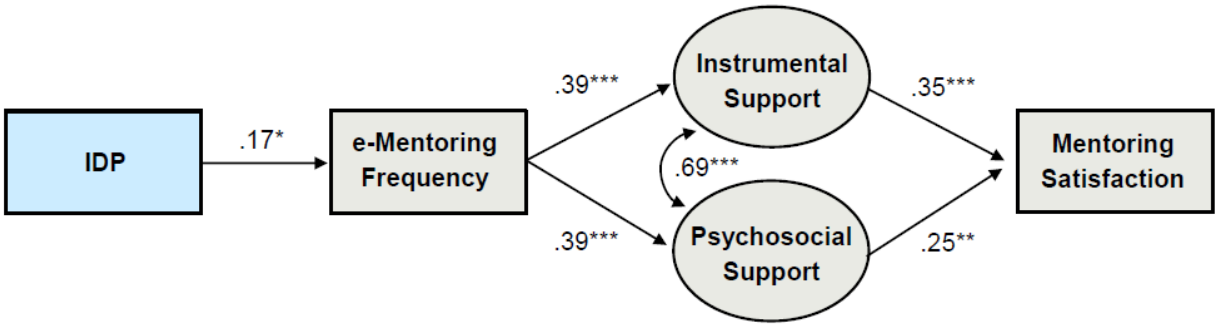

Figure 14. SEM Results for the Relationships between the Use of IDPs and Mentoring Process during the COVID-19 Pandemic

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 were controlled. *p<.05, **p<.01, ***p<.001.

Discussion

During the COVID-19 pandemic, e-mentoring has become an emerging approach for faculty to continue to support students. The present study investigated 566 engineering graduate students' e-mentoring experience and academic, career, and mental health outcomes during the COVID-19 pandemic. Our results indicate that the COVID-19 pandemic negatively affected several student outcomes, especially among females, low-SES students, international students, and students with disabilities. Overall, approximately 25% of engineering graduate students were expected to delay their graduation. Engineering graduate students also felt less confident in their future job search and experienced symptoms of depression and anxiety several days a week on average.

Although traditional face-to-face mentoring was limited during the pandemic, our study showed that the mentor-mentee activities shifted to virtual platforms. Specifically, e-mentoring hours through video conferencing and emailing significantly increased during the COVID-19 outbreak. The SEM results confirmed that the proposed conceptual models for e-mentoring fits the empirical data adequately. The findings suggest that e-mentoring frequency is positively related to perceived mentoring support, which contributes to mentoring satisfaction. More importantly, mentoring satisfaction was positively associated with student academic, career, and mental health outcomes. E-mentoring attitude and the use of IDPs (a proxy for a stronger mentor-mentee relationship) benefit the entire e-mentoring experience, which in turn enhances student outcomes.

While the findings of this study show crucial implications for research on e-mentoring experience and student outcomes among engineering graduate students, there are several limitations to this study. First, it was a cross-sectional study, which primarily tested the relationships among mentoring experience and student outcomes at a single point in time (June

2020). Therefore, our study cannot infer the longitudinal effect of e-mentoring on student outcomes. Second, our study lacked pre-COVID-19 baseline data. Our pandemic impact measures were primarily collected by asking participants to retrospectively compare their experiences prior to COVID-19 to their current experiences. While retrospective data collection my increase measurement error, we believe it is an acceptable strategy under the current circumstance. Finally, our sample is not nationally representative. Nonetheless, our survey sample included a diverse group of engineering graduate students from 44 higher education institutions in 16 states.

Despite these limitations, this study makes several theoretical, methodological, and practical contributions to the literature on e-mentoring, engineering graduate education, and crisis management. First, it extends and empirically tests the applicability of a well-established Mentoring Input-Process-Output (MIPO) model, derived from studies on traditional mentoring, in e-mentoring settings[14], [17]. Second, this study represents the first study investigating the interrelationships among e-mentoring experience and student outcomes during the COVID-19 pandemic with a diverse sample of engineering graduate students, which allows greater generalizability than prior e-mentoring studies [12], [13]. Third, it documents that the academic progress, career self-belief, and mental health of underrepresented groups—females, lower SES students, and students with disabilities—were disproportionately negatively affected by the COVID-19 pandemic. Fourth, and importantly, the e-mentoring inputs and processes are positively associated with mentoring satisfaction, which in turn positively linked to student academic, career, and mental health outcomes. In short, our study suggests that mentoring via electronic technology during uncertain times can alleviate the negative crisis effects and improve positive outcomes for mentees, in our case, engineering graduate students.

Acknowledgements

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