Board 89: Work in Progress: Promoting Undergraduate Student Success through Faculty Mentoring in Engineering Education

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Introduction

The transition from high school to college can present significant challenges for students, creating a need for a strong support system. In modern engineering education, mentoring has emerged as an important component in supporting the growth and success of undergraduate students. It is generally recognized that relationships with faculty members impact student success[1]. Mentoring has gained significant attention for its role in providing personalized guidance and fostering a sense of belonging within the community.

Mentors play an important role in helping students navigate academic challenges and make well-informed decisions[2]. Furthermore, the mentor-mentee relationship establishes a nurturing atmosphere dedicated to enhancing academic performance. While much of the existing research in this field focuses on mentoring research activities between students and advisors, as well as peer advising, limited attention has been paid to a more general advising role.

This comprehensive advising role covers a range of aspects, including assistance with course selection, exploration of technical interests, guidance in finding internships or research opportunities, support in graduate school applications, facilitation of extracurricular activities, and advice on study abroad opportunities. It also involves offering support for personal or mental health concerns. The research presented in [3] demonstrates some progress in this direction, yet there is no one-size-fits-all rule for mentoring, as its efficacy depends on multiple factors specific to a particular university, such as school size, proportion of students to mentors, etc.

This work in progress aims to understand the needs and expectations of students who are supported by a faculty mentoring process in an Electrical and Computer Engineering (ECE) department in a large public university. The goal of the program is to offer additional and personalized support to students supplementing the departmental academic advising service dedicated to addressing curriculum-related questions. The topics covered during these sessions are diverse, as mentioned earlier.

In Fall 2023, the ECE department had 2,310 undergraduate students. Typically, each faculty member is randomly assigned around 30-35 students of different academic levels every semester. Most students are paired with a specific faculty member from their freshman year and maintain this mentor-mentee relationship until graduation. Students also have the option to choose a

different faculty mentor if the existing relationship proves ineffective. It is important to note that a faculty mentor's research area doesn't necessarily match the area of interest of their mentees.

Currently, the program involves students meeting their assigned faculty mentors once per semester. These mentoring meetings are mandatory for students, and failing to attend the meeting results in a hold on their upcoming semester's class registration. Students are responsible for scheduling appointments based on faculty members' availability calendars.

From the faculty's perspective, they have the freedom to choose the approach for conducting these meetings. For instance, meetings can take the form of one-on-one private conversations or group sessions. They can also occur either in person or online. Faculty can also select a duration for the meeting between 15 and 60 minutes.

Each approach has its own set of advantages and drawbacks. For instance, one-on-one mentoring can offer highly personalized guidance and support. However, group mentoring provides diverse perspectives from student peers and creates networking opportunities. Moreover, as demonstrated in [4], peer mentoring has been shown to enhance both retention and self-esteem among college students.

Methodology

In Fall 2023, three faculty members within the ECE department conducted one-on-one, in-person meetings with their mentees. Each faculty member allocated 15-30 minute time slots to meet with students. Following these meetings, mentors invited their mentees to voluntarily participate in an online survey designed to gather information about students' experiences and preferences regarding various aspects of the mentoring process. Students had the option to complete the survey immediately after the meeting or at a later time. In total, 56 out of 87 students opted to participate. Among these, there were 6 freshmen, 7 sophomores, 18 juniors, and 25 seniors. The participants included 45 male students and 11 female students.

The survey addressed seven key topics: student expectations, level of support, comfort in discussing academic topics, non-academic subjects, logistical aspects, stress levels, and suggestions for improvements. Most of the questions utilized a Likert scale ranging from 1, indicating disagreement, to 5, indicating agreement. Six questions were open-ended. The survey questions and their categorization are presented in the Table 1.

Question #	Question	Category
Q3	To what extent has the mentoring meeting met your expectations?	Student expectations
Q4	How supportive has your faculty mentor been about your professional goals?	Level of support
Q5	How supportive has your faculty mentor been about your academic goals?	
Q6	How supportive has your faculty mentor been about your life goals?	
Q7	How easy has it been to discuss ideas about elective options with your faculty mentor?	Comfort level in academic topics discussion
Q8	How easy has it been to discuss ideas about career options with your faculty mentor?	
Q9	How easy has it been to discuss ideas about internship options with your faculty mentor?	
Q10	How easy has it been to discuss ideas about research options with your faculty mentor?	
Q11	How helpful has your faculty mentor been in balancing your class schedule with other obligations?	Non-academic topics
Q12	How well has your faculty mentor helped you in developing better time management skills?	
Q13	In general, how helpful have you found the mentoring meeting?	
Q14	Please explain your answer to the question above (open-ended)	
Q15	Has the allocated time been sufficient to address all your questions?	Logistics
Q16	Do you think the mentoring meetings should be optional? Why or why not? (open-ended)	
Q17	How often do you think mentoring meetings should be held?	
Q18	Which type of mentoring meeting do you prefer?	
Q19	How stressful has it been to talk to your mentor?	Level of stress
Q20	How stressful has it been to come up with questions before the meeting?	
Q21	What topics would you like to discuss during mentoring meetings?	Suggestions/ improvements (open-ended)
Q22	What resources do you think your mentor should provide during mentoring meetings?	
Q23	What else would you like to address during the mentoring meeting?	
Q24	How can the mentoring meetings be more beneficial for you?	

Table 1: Categorized survey questions.

Next, factor analysis, both exploratory and confirmatory, was conducted to gain a better understanding of the relationships between the survey questions. Exploratory Factor Analysis (EFA) is used to explore the variables and propose factors and factor loadings. The analysis was carried out using IBM's SPSS under its Maximum Likelihood (ML) mode and a Varimax rotation, with coefficients below 0.5 discarded in the component matrix [5]. Confirmatory Factor Analysis (CFA) begins with a proposed factor model and verifies its appropriateness for the variables involved. We performed a first-order Confirmatory Factor Analysis (CFA) via IBM's AMOS using the results obtained from the EFA.

In addition to the factor analysis, we have conducted several tests using IBM SPSS and AMOS to assess the model's fit to the data. These tests include: The Kaiser–Meyer–Olkin (KMO) test, Bartlett's test, Cronbach's alpha, and the goodness-of-fit test. Additionally, we performed EFA using principal component analysis (PCA) and principal axis factoring (PAF) techniques.

Finally, Independent Samples t-Tests and Analysis of Variance (ANOVA) were conducted using IBM SPSS to determine if there were significant differences in responses, based on gender, grade, or particular faculty member.

Findings

Findings on the relationships among the survey questions

Firstly, we present the results of EFA over all the Likert questions. The analysis indicated that questions 15, 17 and 18 have large significance values in the correlation matrix. These questions also demonstrated low communality extraction values and low factor loading values, indicating that they do not contribute significantly to the factors that were extracted. Therefore, we removed these questions from the factor analysis.

Next, we repeated the analysis on the reduced set of questions. The analysis resulted in a two-factor solution, indicating that only two latent variables are required to represent all the questions involved. The scree plot also indicated a two-factor solution. Factor loading with and without rotation yielded all Likert questions except for Q19 and Q20, on one factor, as shown in Figure **??**.

Upon careful examination of the collective measurement of these questions (see Table 1), it became evident that they represent a measure of satisfaction with the mentoring experience, essentially duplicating Q3. Consequently, Q3 was also excluded from the factor analysis. It was also observed, that questions Q19 and Q20 (Table 1) loaded onto the other factor do not measure satisfaction with mentoring but rather stress levels.

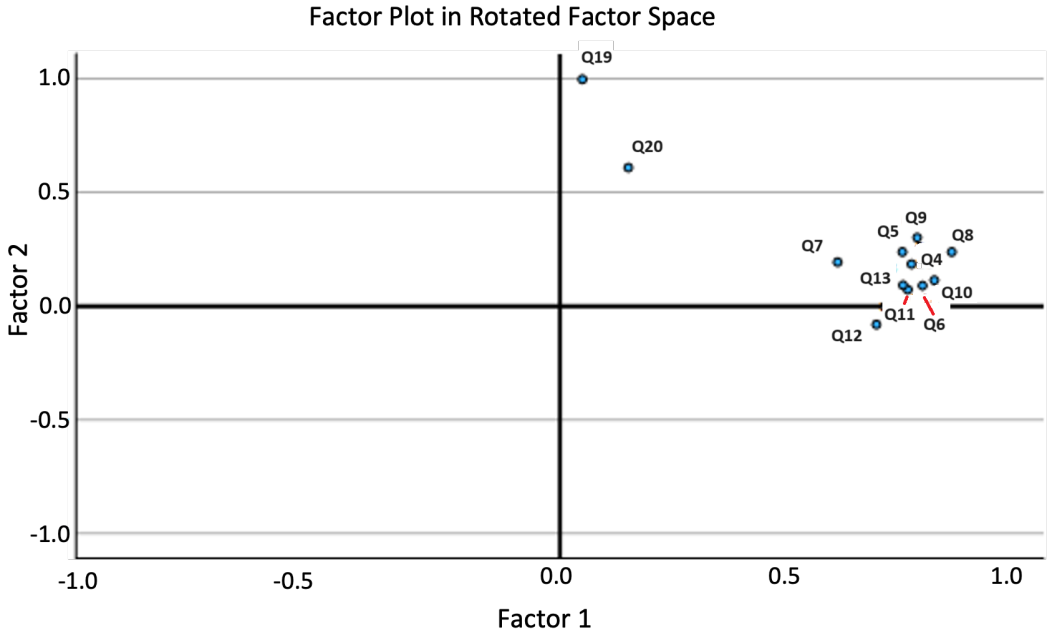

Figure 1: Factor plot in the rotated factor space for questions Q4-Q13 and Q19-Q20.

Finally, the factor analysis was carried out again with the reduced set of questions (Q4-Q13 and Q19-Q20). As a result, the same two factors were obtained, with the first and second factors contributing 53.4% and 14.04% after the Varimax rotation.

Findings on the on the model's fit to the data

First, we have observed that the determinant of the correlation matrix was 1.89E-5, exceeding the recommended threshold of 1E-5 value [6]. This result indicates that the various survey components are not co-linear, they measure distinct features within the overall satisfaction.

Additionally, The Kaiser–Meyer–Olkin (KMO) test yielded a value of 0.861, indicating excellent sampling adequacy [7]. This implies that the variables in the analysis are suitable for factor

analysis. Bartlett's test of sphericity produced a Chi-Squared value of 545.43 with 66 degrees of freedom and a significance below 0.001, indicating that the variables are sufficiently related for meaningful exploratory factor analysis (EFA) [8]. The Cronbach's alpha value of 0.928, exceeding the 0.7 threshold, suggests high reliability of the model. The goodness-of-fit test resulted in a Chi-Squared value of 88.97 with 43 degrees of freedom and a significance below 0.001, indicating a strong model fit. Additionally, we conducted EFA using principal component analysis (PCA) and principal axis factoring (PAF) techniques, yielding highly similar results.

Next, we present the results of a first-order Confirmatory Factor Analysis. The results are illustrated by the diagram shown in Figure 2.

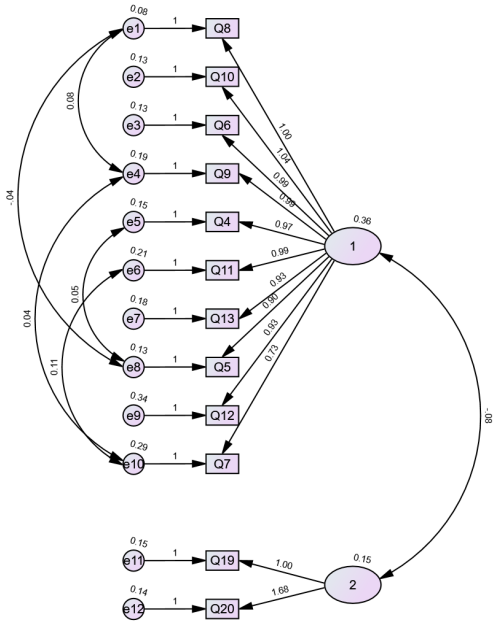

Figure 2: CFA diagram for observed variables Q4-Q13 and Q19-Q20, in rectangles; and latent variables 1 and 2, in ovals.

The standardized estimated regression weights are shown in the diagram as the numbers above the arrows connecting the latent variables (ovals) to the observed variables (rectangles). The smallest weight, 0.73, is associated with Q7, while the largest weight, 1.68, is linked to Q20. A standardized estimated regression weight of 0.73 on Q7, for instance, indicates that a one-unit increase in latent variable 1 corresponds to a 0.73 unit increase in Q7.

We used modification indices to covary observed variables to improve the model, as indicated by the double arrows on the far left connecting the corresponding error terms. The resulting standardized residual covariances are less than 1.476 in absolute value, which falls below the recommended threshold of 2.58. Therefore, there are no significant discrepancies between the proposed and estimated models. Table 2 describes the obtained factor model fit under various

metrics, clearly indicating that the fit is excellent.

Measure	Estimate	Threshold	Interpretation
CMIN/DF	1.22	(1,3)	Excellent
CFI	0.98	>0.95	Excellent
SRMR	0.061	<0.08	Excellent
RMSEA	0.063	<0.06	Acceptable
PClose	0.339	>0.05	Excellent

Table 2: Model fit measures.

Findings on gender, grade, and instructor-related bias

Firstly, we present the results of Independent Samples t-Tests to access potential gender-based differences in survey responses. We compared the mean scores between 45 male and 11 female participants as shown on Figure 3.

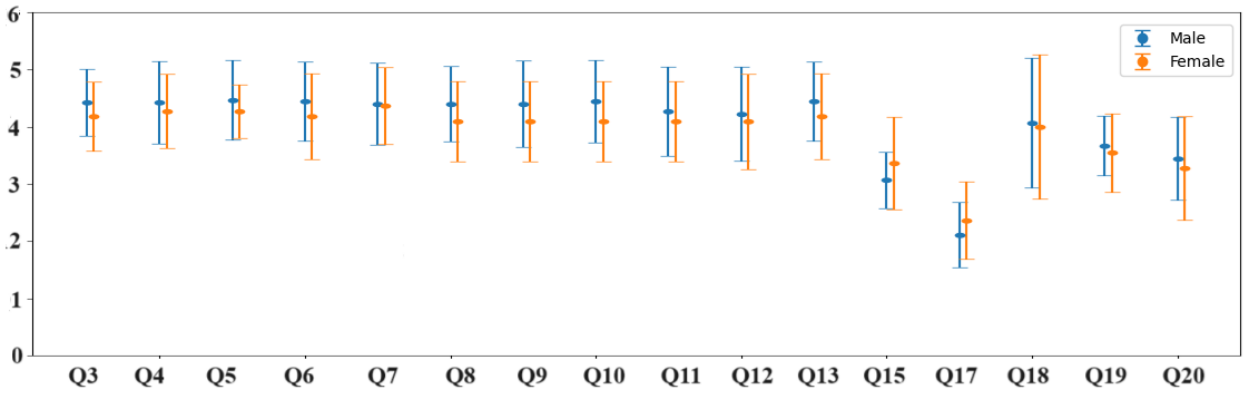

Figure 3: Means and standard deviations for all Likert questions, for male and female students.

The findings show no significant gender-based differences concerning faculty support for academic goals. Male students reported a mean of 4.4667 for academic goals, while female students reported 4.2727. Similar trends were observed for professional and life goals.

Concerning the ease of discussing various options with faculty mentors, no significant gender discrepancies emerged. Both male and female students exhibited similar levels of comfort discussing elective, career, internship, and research opportunities.

Regarding Q3 (”To what extent has the mentoring meeting met your expectations?”), both male (Mean = 4.4222) and female (Mean = 4.1818) students perceived the meetings positively, with slight variations in mean scores.

In summary, the results indicated no statistically significant differences between male and female students for any of the survey questions (all p-values > 0.05). The analysis suggests that gender

does not seem to be a significant factor influencing students' perceptions of mentoring experiences within the ECE department.

Next, we present the results of the one-way ANOVA analysis on potential grade-based differences. In total, 6 freshmen, 7 sophomores, 18 juniors, and 25 seniors participated in the survey. The means and standard derivations are presented in Figure 4.

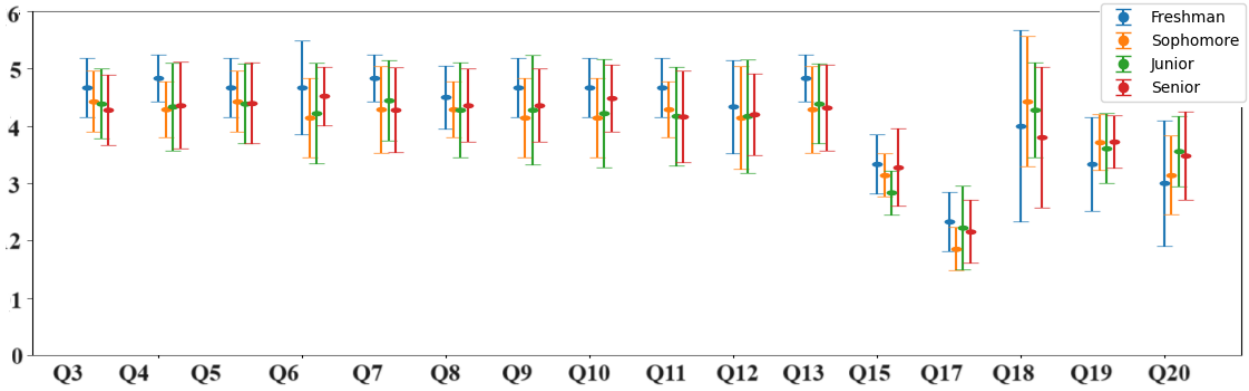

Figure 4: Means and standard deviations for all Likert questions, for each of the four different grade levels: freshmen, sophomores, juniors and seniors.

The findings indicate significant differences between grade levels for the following questions:

- Q6: How supportive has your faculty mentor been about your life goals? (p-value = 0.029)

Authors believe that the variance in feedback on faculty mentor support for life goals across grade levels can be attributed to students' evolving expectations and experiences. Freshmen (Mean = 4.67) may receive more general feedback on adjusting to college life, while seniors (Mean = 4.52) might focus more on discussing future career choices during mentorship sessions. Sophomores (Mean = 4.14) and juniors (Mean = 4.22) may not have as clear life goals for discussion during mentor meetings.

- Q9: How easy has it been to discuss ideas about internship options with your faculty mentor? (p-value = 0.002)

The data suggested a subtle variation in students' perceptions regarding discussing internship options with faculty mentors across various grade levels. Authors suggest that this could be attributed to freshmen (Mean = 4.6667) potentially finding such discussions relatively easier, perhaps due to their enthusiasm and eagerness for new experiences. Sophomores, with a slightly lower mean of 4.1429, may be navigating the transition to more specialized topics and feeling uncertain about internship choices. Juniors and seniors, both exhibiting mean values around 4.3, likely have previous internship experiences and show readiness for further internship opportunities.

- Q10: How easy has it been to discuss ideas about research options with your faculty mentor? (p-value = 0.001)

The data indicated varying perceptions among students across various grade levels. Freshmen, boasting the highest mean of 4.67, may demonstrate a strong interest in exploring research opportunities early in their academic journey. Sophomores and juniors, with mean values of 4.14 and 4.22 respectively, might be adjusting to more advanced research concepts while also pursuing internship and club experiences. Seniors (mean = 4.5) could potentially be influenced by increased exposure to research over the course of their academic advancement.

- Q12: How well has your faculty mentor helped you in developing better time management skills? (p-value = 0.023)

According to the data, freshmen (mean = 4.3333) may perceive their faculty mentors as particularly helpful in developing time management skills. This observation could possibly stem from the fact that freshmen are transitioning from high school to college life, during which they require effective time-management strategies.

Finally, we provide the findings of the one-way ANOVA analysis regarding potential variances attributed to instructors (Figure 5).

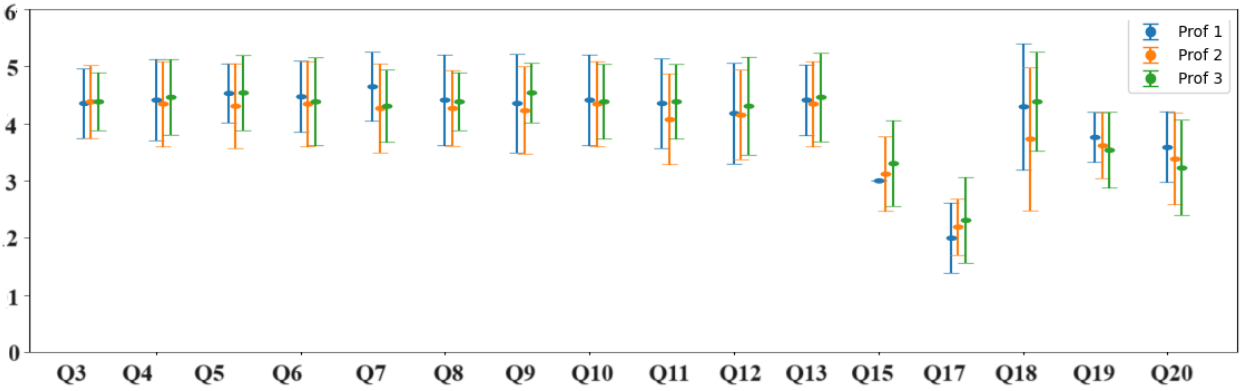

Figure 5: Means and standard deviations for all Likert questions, evaluated for three instructors.

The findings indicate that, among the three different mentors, students' feedback showed no significant differences in almost all questions, except for one regarding the sufficiency of allocated time (p-value = 0.002). Mentors who allocated 25 minutes for discussion, with an additional 5 minutes for survey completion, received higher mean scores compared to the one who allocated only 15 minutes. Interestingly, this suggests that students may benefit more from longer meeting durations, potentially feeling more at ease during discussions with their mentors. However, this observation contrasts with the fact that students reported being able to cover all topics of interest in the other questions. Additionally, it's worth noting that for mentors with longer meeting durations, students utilized the entire allocated time, possibly indicating a willingness to extend discussions. Conversely, for the mentor with 15-minute meetings, students often concluded discussions early. In the next phase of the work, we will look deeper into these patterns.

Conclusions

In this work in progress, we analyze the results of the survey aiming to gain insights into the needs and expectations of students benefiting from faculty mentoring within the ECE department of a large public university. The survey addresses seven key topics: student expectations, support levels, comfort discussing academic and non-academic topics, logistical aspects, stress levels, and suggestions for improvements.

First, our results confirmed the validity of the survey we developed, demonstrating that different survey components measure distinct features within the overall satisfaction. Additionally, we verified the high reliability of the model and its excellent fit to the data.

Next, our findings suggest that there are no statistically significant differences between male and female students for any of the survey questions, indicating that gender does not appear to significantly influence students' perceptions of mentoring experiences within the ECE department.

However, our findings show significant differences among 4 out of 24 survey questions across students of different academic levels. We attribute the difference to factors specific to individual student levels, including prior internship experience, current interest in research, and the importance of time-management skills.

Moreover, our findings suggest a potential bias related to instructors regarding the sufficiency of meeting time, indicating that longer durations may potentially enhance student comfort. However, it contradicts with students reporting satisfaction in covering all topics of interest during meetings. Additionally, the instructor with the shortest meeting duration noted that often students finished discussions before the allocated time ended.

For the next phase of our work, we intend to shift the mentoring meetings to a small group format. Additionally, we plan to distribute surveys once more to gather feedback from students.

In the broader scope, our long-term strategy includes expanding the study by incorporating more faculty members from the ECE department. This expansion aims to increase the number of participants as well as to understand faculty's perspectives, ultimately contributing to the development of comprehensive guidelines for mentoring meetings. These guidelines will be particularly beneficial for new faculty members who are leading these sessions for the first time, enhancing the overall effectiveness of the mentoring process.

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