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Interactions with Faculty and Engineering Self-Efficacy Among Underrepresented Engineering Persisters

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***Abstract* - Theoretical frameworks on persistence and success in higher education emphasize the important role of student-faculty interaction. Research on student success in engineering education has supported this notion. The current study examined survey questionnaire data from a sample of engineering persisters (juniors and seniors) at a diverse urban research institution in the Southeastern US (n=272) to understand the relationship of student-faculty interaction and perceived relationship quality with perceived engineering self-efficacy (ESE). Students were asked to indicate frequency of types of interactions with faculty (e.g., discuss plan of study; discuss future career plans) and extent to which they experienced negative attitudes from faculty. Engineering self-efficacy (e.g., succeed in engineering curriculum; excel in engineering major) was assessed using items from a published instrument on engineering self-efficacy, and the scale demonstrated internal consistency. Overall, students who reported more frequent interactions with faculty (more than once), and lower perceived negative attitudes from faculty indicated higher levels of engineering self-efficacy. Further, we examined results for sub-groups of specific underrepresented students (women; transfer students; first-generation students). The findings underline the importance of type and frequency of interactions with engineering faculty and perceptions of positive and supportive relationships for self-efficacy and persistence in engineering.**

Keywords: engineering self-efficacy; student-faculty interaction

I. INTRODUCTION

The importance of the role of student-faculty interaction (SFI) in student success has been emphasized by several predominant theoretical frameworks on student persistence and academic success in higher education [1-2]. Although there are many factors that influence student success, researchers seem to agree that SFI has a direct impact [3-7]. Faculty impact student aspirations to achieve at a higher level, a significant increase in feelings of confidence of academic skills, and an enhancement of intellectual self-concept [8-9]. This notion has been supported by research on student success in engineering education.

These interactions are vital to the success of all engineering students, but especially those from underrepresented racial/ethnic minority (URM) groups. Research over the past 15 years has evidenced the relationship of SFI with persistence, academic performance, and academic and personal growth for underrepresented students in STEM disciplines, including engineering. In particular, underrepresented students of color (i.e., Black, Latino, Native American) in STEM disciplines benefit greatly from faculty-student interactions. Frequent interactions and support from faculty have been found to be linked with higher grades [10] and may lead to higher academic performance even if students had low testing performance prior to college [11]. While interactions related to course materials may not relate to higher GPA [10], conducting research with faculty members is associated with improvements in academic performance [12-13]. Overall, engineering students' interactions with faculty are vital for persistence and retention [14-16] and are especially critical for Black and Latino students in ensuring their academic success [10], [17-18]. However, research indicates that while URM engineering and STEM students tend to have frequent interactions with faculty, they may feel less satisfied with those interactions since they are less meaningful and are less likely to engage in undergraduate research with faculty members [19-21].

As part of a larger, federally-funded, mixed-methods project on the role of student-faculty interaction for the persistence of underrepresented racial/ethnic minority (URM) students in engineering, the authors gathered data from undergraduate engineering persisters (junior and senior students) using an online questionnaire. This questionnaire included support and interactions prior to enrolling in engineering, frequency of out-of-class interactions with faculty, assessment of quality of relationships with faculty, students, and staff, barriers experienced during studies, engineering self-efficacy, and cultural wealth. For this study reported herein, we

focused specifically on the extent to which perceived relationships with engineering faculty are related to engineering self-efficacy (ESE).

II. ENGINEERING SELF-EFFICACY

Self-efficacy is defined as a person's belief in their ability to perform well within a particular discipline [22]. The importance of self-efficacy is perhaps markedly more pronounced in engineering programs given the academic rigor and intensity of the coursework. Traditionally used measures of self-efficacy include The General Engineering Self-Efficacy Scale and the Engineering Skills Self-Efficacy Scale and both instruments have been proven reliable, valid, and useful in the assessment of undergraduate engineering students [23].

Self-efficacy as an independent variable

ESE has long been studied to determine its relation to retention, persistence, and overall success among students in the field. Aleta [24] reported that students who judged their own engineering backgrounds as strong and positive were more likely to perform well in engineering programs and on engineering exams, and their engineering self-efficacy was also shown to be correlated with academic achievement. Other research has been dedicated to the intersections of self-efficacy and gender. Marra, Rodgers, Shen, and Bogue [25] found that among women in male-dominated academic domains, self-efficacy was particularly important in giving them the wherewithal to persist. In addition, women's levels of self-efficacy often increase as they continue in their program, though their measures of inclusion often decline. Women's perception of sexism or prejudice also negatively impacted their feelings of self-efficacy related to engineering degree completion [26].

Self-efficacy as a dependent variable

Micari and Pazos [27] reported that self-efficacy acts as a mediating factor between both instructor connectedness and satisfaction and peer alignment and satisfaction with engineering. This means that as a result of increasing instructor connectedness, peer alignment or both, students levels of self-efficacy also increase which subsequently causes an increase in satisfaction with their program of study. In addition to these variables, students who have taken pre-engineering courses and who have engineering hobbies often have higher measures of self-efficacy than those who do not [28]. Engagement in engineering sponsored programs, such as ambassador programs, have also been shown as factors contributing to an increase in ESE [29]. Other factors such as obtaining good grades, exposure to positive role models, and receiving positive feedback from professors or mentors are also credited with augmenting engineering students' self-efficacy [30].

There has been little scholarship that links SFI with self-efficacy for engineering students. The current study attempted to address this gap by examining data from junior and senior engineering students at one urban institution.

III. METHODOLOGY

A. Design

The current exploratory study examined survey questionnaire data from a sample of engineering junior and senior persisters (n=272), at a diverse urban research institution in the Southeastern US, to understand the relationship of student-faculty interactions and perceived relationship quality with ESE. Students were asked to indicate frequency of types of interactions with faculty (e.g., discuss plan of study; discuss future career plans), perceptions of faculty support, extent to which they experienced negative attitudes from faculty, whether they draw on

connections with faculty to be successful, and level of confidence in approaching faculty for assistance. ESE (e.g., succeed in engineering curriculum; excel in engineering major) was assessed using items from a published instrument on ESE and the scale demonstrated internal consistency.

B. Instrumentation

As part of the larger project, an online survey questionnaire collected data concerning support and interactions prior to enrolling in engineering studies, frequency of out-of-class interactions with engineering faculty, assessment of quality of relationships with engineering faculty, students, and staff, barriers experienced during studies, engineering self-efficacy, and cultural wealth. The focus of this study is on the frequency and types of interactions and how students perceived faculty attitudes.

1) *Frequency of interactions and perceived attitudes of faculty:* Students indicated the frequency of interaction with engineering faculty during the past 12 months for four types of interactions; 1) discussed plan of study, 2) discussed ideas, readings, assignments (class-related), 3) discussed involvement in research project, internship, and part-time jobs (enriching activities), and 4) discussed future career plans; with possible ratings of "never", "once", and "more than once". Students also reported on the frequency of perceived negative attitudes of faculty including three ratings: "not at all", "a little", and "to a great extent".

2) Engineering self-efficacy: In the broader study, seventeen (17) items related to ESE [44,45] were included on the survey questionnaire used for this study (see Table 1). Items were rated on a 7-point scale from 1=strongly disagree to 7=strongly agree, as in the original instrument. Exploratory factor analysis to identify factors among these items supported a two-

factor model – engineering self-efficacy (ESE, 5 items), and coping self-efficacy (CSE, 5 items). However, only ESE is examined in this current study (Table 1).

TABLE 1. ENGINEERING SELF-EFFICACY SUBSCALES (n=272)

Scale	**Item**	**Mean (SD)**
ESE α=0.80	I can succeed in an engineering curriculum.	6.42 (0.68)
	I can succeed in an engineering curriculum while not having to give up participation in outside interests.	4.49 (1.97)
	I can excel in an engineering major during the current academic year.	6.01 (1.06)
	I can complete any engineering degree at this institution.	5.73 (1.35)
	I can succeed (earn an A or B) in an advanced engineering course.	5.66 (1.30)

C. Participants

Participants in the study were students who identified as engineering majors in their junior or senior year of study at the urban research institution. The majority of participants identified as male (81%) and nearly three-quarters of participants identified as White (74%); these proportions are reflective of the engineering student population at the institution. Transfer students comprised a little over half of the sample (55%), with a plurality of students reporting that neither parent had obtained a college degree (38%). Based on lack of racial/ethnic diversity in the sample, researchers did not examine differences in engineering self-efficacy based on student-faculty interaction for racial/ethnic subgroups.

D. Analysis

Descriptive statistics were used to examine the items prior to inferential analysis. We utilized ANOVA to compare engineering self-efficacy based on frequency of interactions with faculty and perceived faculty attitudes. The first comparisons were calculated on the entire sample followed by separate analyses of subgroups based on gender, transfer status, and first-generation status. We examined post-hoc pairwise comparisons (LSD and Tukey's HSD) to determine the nature of group differences. All analyses were conducted using IBM SPSS 22.0.

IV. FINDINGS

A. Differences in Engineering Self-Efficacy Based on Interactions with Faculty

As shown in Table 2, students reported significant differences in engineering self-efficacy (ESE) based on frequency of discussions with engineering faculty across all four types of discussions, with some variation when looking at demographic subgroups based on gender, transfer status, and parent education.

Table 2. DIFFERENCES IN ENGINEERING SELF-EFFICACY BASED ON FREQUENCY OF INTERACTIONS WITH ENGINEERING FACULTY, FOR ALL STUDENTS AND BY SUB-GROUPS (n=272)

		F (significant pairwise comparisons)[1]			
Group		Discuss plan of study	Discuss class-related topics	Discuss enriching activities	Discuss future career plans
All		4.98** (a**)	4.08* (a**)	13.02*** (a***, b***)	10.42*** (a***, c**)
Gender	Female (n=54)	2.90 -	5.34** (a**, c*)	2.70 -	4.09* (a**)
	Male (n=218)	2.80 -	1.95 -	9.32*** (a***, b**)	5.02** (a**, c*)
Transfer Status	Transfer (n=148)	3.26* (b*)	0.87 -	7.92** (a**, b**)	1.84 -
	Native (n=124)	2.03 -	4.60* (a**, c*)	5.54** (a**, b*)	9.35*** (a***, c**)
Parent education	First generation (n=104)	4.80* (a**, c*)	6.52** (a**, b*)	6.60** (a**, b**)	7.72** (a***, c*)
	Non-first generation (n=168)	2.61 -	0.68 -	7.21** (a**, b**)	3.32* (a*)

[1] a=more than once > never; b=more than once > once; c=once > never

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

Three types of significant pairwise comparisons were found in the results, outlined in the footnotes to Table 2 (a, b, and c). Based on these significant pairwise comparisons, three patterns could be noted across the results: 1) ESE higher only when student interacts more than once (a only); 2) ESE increases with frequency of interaction (a and b); and 3) ESE higher for ever interacting with faculty (a and c).

In the full sample, ESE was significantly higher among students who reporting having discussions more than once about plan of study and class-related topics. For discussions about involvement in enriching activities (research projects, internships, part-time jobs), ESE significantly increased with frequency of discussion. Additionally, ever discussing future career plans was associated with higher ESE. Some variations were noted within the demographic subgroups.

1) *Gender*: For female engineering students (n=54), discussing class-related topics with engineering faculty (at least once and more than once) was associated with higher levels of ESE. ESE was also significantly higher for female students who reported having discussions regarding future career plans more than once. In contrast, increased frequency of discussions about enriching activities was associated with higher ESE for male students (n=218), as well as ever discussing career plans with faculty.

2) *Transfer status*: For transfer students in the sample (n=148), ESE was significantly higher for two types of discussions; plan of study and enriching activities; and only if those interactions occurred *more than once*. Native students' responses showed a different profile; ever having a discussion with faculty (once or more than once) about class-related topics and future career plans was associated with higher ESE; while ESE was significantly higher with increased frequency of discussions about enriching activities.

3) Parent education: For first-generation engineering students (n=104), frequency of discussion across all types was associated with higher ESE. Ever having discussions about plan of study and future career plans was linked to higher ESE. ESE increased with frequency of discussions about class-related topics, and involvement in enriching activities. For students from families where at least one parent obtained a college degree, ESE significantly increased with frequency of discussion about enriching activities, and when discussing future career plans more than once.

B. Differences in Engineering Self-Efficacy Based on Perceived Negative Attitudes From Faculty

As shown in Table 3, extent of perceived negative attitudes from faculty was significantly related to ESE among engineering students in the sample. However, when looking at demographic subgroups, differences were only seen for two groups - males and first generation students. For both subgroups, students reported significantly higher ESE when they perceived no or little negativity from faculty (compared to those who perceived negative attitudes to a great extent).

Table 3. DIFFERENCES IN ENGINEERING SELF-EFFICACY BASED ON EXTENT OF PERCEIVED NEGATIVE ATTITUDES FROM FACULTY, FOR ALL STUDENTS AND BY SUB-GROUPS (n=272)

		F (significant pairwise comparisons)[1]
Group		Negative attitudes from faculty
All		3.27* (a**, b*, c*)
Gender	Female (n=54)	1.24 -
	Male (n=218)	5.02** (a***, c**)
Transfer Status	Transfer (n=148)	1.65 -
	Native (n=124)	1.67 -
Parent education	First generation (n=104)	4.48** (a**, c*)
	Non-first generation (n=168)	1.73 -

[1] a=not at all > a great extent; b=not at all > somewhat; c=a little > a great extent
*p<.05, **p<.01, ***p<.001

IV. DISCUSSION AND IMPLICATIONS

The findings of this study suggest the importance of communication and perceived positivity from engineering faculty members for feelings of engineering self-efficacy (ESE) among engineering students. Across most demographic subgroups, frequency of discussions

about enriching activities and future career plans had a significant relationship with ESE. More frequent discussions about enriching activities may suggest that students are also participating in these activities (research, internships), but it is not possible to determine based on the question wording in the survey.

For underrepresented student groups in the sample; women, transfer students, first-generation college; the pattern of significant interactions was not consistent. Frequency of discussions about class-related topics and future career plans were significantly related to ESE for women and first-generation college students, but not for transfer students. While discussing plan of study with faculty and discussing enriching activities were significant for transfer and first-generation students, neither was significant for women's ESE. Perceived negative attitudes from faculty only showed significant effects on ESE for first-generation students.

Research on the role of student-faculty interaction for the persistence of female students has pointed to the importance of respectful classroom interaction [14] and to having interactions about course-related issues [13], similar to findings in the current study about the effects of discussing class-related topics on women engineering students' ESE. While there is limited research on engineering transfer students, recent studies suggest the importance of coordinated advising in the first term of the transition to ensure student persistence and success [31,32], aligning with the current study's results that found discussing plan of study to be significant for transfer student ESE. While first-generation college students may interact less frequently with faculty , the benefits of course-related interactions with faculty include increased aspirations, communication skills, and critical thinking skills [13]. Recent research has illustrated the importance of perceived accessibility of faculty for first-generation engineering students from URM groups to feel "validated" in engineering [33]. First-generation students were the only

underrepresented group in the current study that showed a significant effect of perceived negative faculty attitudes on engineering self-efficacy.

Results and limitations of the current study point to implications for future research on student-faculty interaction and engineering self-efficacy among underrepresented students in engineering. While it appears that frequency of discussions can play an important role, greater information is needed about the nature and context of such discussions; when they occur, with what frequency (if more than once), characteristics of the faculty members that participate in the interactions, what was discussed, and which types of interactions are preferred by students. Additionally, we could not know whether discussions about opportunities or career led to particular actions or benefits for students. There is room for additional quantitative work, to examine the conditional effects of interactions with faculty on ESE based on student demographic characteristics - to help "maximize the educational efficacy of student–faculty interaction by minimizing the ... differences associated with it." [13, p. 453]. Clearly, qualitative research on student-faculty interaction in engineering can illuminate the rich context of interactions and how interactions contribute to students' sense of self-efficacy in engineering.

The findings of this study suggest several key implications for practice. Engineering faculty should note that advising and office hours can make a difference for URM students to feel confident and remain in engineering. Suggesting or discussing opportunities and career plans with students can enhance their feelings of self-efficacy to become an engineer. Best practices in student advising indicate the benefits of presenting student with career enhancing opportunities such as undergraduate research, internships, job opportunities, and graduate studies, which could translate into improved self-efficacy and persistence. The significance and impact of student-faculty interactions for self-efficacy of URM students warrants implementation of institutional

support for faculty mentors. Academic administrators can provide additional support by ensuring that materials and information about plans of study and opportunities for research,internships, and jobs are readily available and accessible to both students and faculty. For the benefit of faculty satisfaction, and promotion and tenure of junior faculty, institutional support could include rewards for faculty interaction with students such as release time and awards or recognition for mentoring. Implementation of such programs may promote greater faculty involvement in such endeavors, which would translate into a greater number and diversity of students reached and thus able to reap the benefits of these important and meaningful interactions.

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