Optimizing Student-Faculty Rapport for the Engineering Classrooms: Dimensioning the Behaviors That Matter

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This research paper describes the findings from an exploratory study. Student retention in engineering disciplines, from program initiation through commencement, is recognized as a challenge by higher learning institutions across the US. Numerous studies have identified that professors who can establish strong and positive rapport with their students have an immediate and positive impact on students' learning, engagement, motivation and academic success, resulting in a positive long-term influence on retention. Previous work has defined fifteen specific faculty behaviors that establish positive rapport between students and professors in other disciplines. However, these past studies may not be generalizable for engineering, and fall short of identifying the differences across student academic maturity and engineering discipline. Given the potential for strong impact on engineering students' experiences, and faculty resource limitations, we sought to elucidate if some behaviors have a higher potential for impact than others, and if so, which faculty behaviors may best contribute to building faculty-student rapport. With these insights, engineering faculty can be trained to selectively focus on those which are expected to have the greatest return on investment. To support the primary aim, students from multiple disciplines in an engineering college were surveyed and asked to rank their perceptions of faculty behaviors that best establish rapport with engineering students. The survey asked students to self identify their gender. This was used to identify how these factors may influence ranking of rapport supportive behaviors. Additionally, this survey asked students both their academic program (the discipline within engineering) and their degree progression, in order to identify how these factors impact such rankings.

Based on findings in the literature, and given the scope of this project, the authors anticipate that the most effective way to broaden students' retention in engineering education is through establishing rapport between engineering professors and their students. Using the results of this study, we can design interventions aimed at faculty member's ability to establish positive rapport, which in turn creates a respectful environment, and removes the barriers to cultivation of diverse student retention in engineering disciplines.

1: Introduction

According to the U.S. Bureau of Labor Statistics, STEM occupations are expected to grow by 8.8% from 9,708.3 (2018) to 10,566.8 (2028). This is a significant growth when compared to the percent growth for all occupations (5.2%). There had been warning signs and continuing concern about the shortage of qualified candidates from a diverse pool to fill these jobs. In this paper we discuss retention in science and engineering, by focusing on specific predictors of persistence including gender, student- instructor rapport, and year of study [1].

1.1: Retention in Science and Engineering

In a 2016 study, nearly half (45%) of all high school seniors indicated an intent to study science and engineering (S&E), yet in the 2015 survey of full-time undergraduates, just more than one third (37%) of undergraduate enrollments were in S&E programs, indicating there exists a disconnect between enrollment and graduation rates. In 2015, out of nearly two-million bachelor's degrees earned; less than one-hundred thousand were in engineering (5.2%) (NSB Appendix Table 2-21 [2]). "We are graduating fewer engineers now than 20 years ago, both in terms of absolute numbers and as a percentage of all college degrees" [3]. This is also reflected in the National Science Board (NSB) cohort study which identified that more than one in six (16.3%) of students who declared their major as S&E at enrollment, were no longer enrolled in any institution three years after their initial college enrollment [2]. These numbers indicate that students lose enthusiasm or interest in S&E somewhere between high school, when many are interested in an S&E career, and graduation. Further, students are aware of this, as nearly half (49%) of surveyed engineering juniors report having doubts about majoring in engineering. Retaining students until graduation is recognized as a challenge by higher learning institutions across the US [4]. Due to the heavy focus on content, engineering in college turns into a "closed club" and becomes less attractive for students to persist in [3].

1.2: Predictors of Persistence

Seymour and Hewitt [5], in a landmark study, stated the concerns about highly qualified students' leaving S&E at about 50% rate, and that ratio heightened at a greater disproportion for women and students of color, despite a serious national effort to improve their recruitment and retention.

Persistence in science and engineering programs can however be partially explained by a known set of variables. For example, learning and course success, directly associated with grades and GPA, are identified as one of the most important predictors of retention [4]. Here we explore two other factors, which we hypothesize have an interaction effect.

1.2.1: Gender

A student's gender has also been identified as a predictor of success in S&E programs [3]. Engineering, excluding computer science, is showing a declining representation of women in contrast to other STEM majors [6]. Although women have nearly the same grades as their male counterparts, women leave engineering in greater percentages than men, often going on to complete other demanding majors [7]. Factors that impact women and other underrepresented minority students' decisions to leave include several academic, social and career issues including, but not limited to, dealing with prejudice, belongingness, lack of academic preparedness, feeling overwhelmed by the pace, poor teaching and being treated differently by faculty [5], [8], [9].

1.2.2: Rapport

One factor not commonly considered, is student-instructor rapport. A student's positive perception of student-instructor rapport is arguably one of the most under-considered factors identified to positively impact retention. Rapport is defined as the feeling of mutual trust and understanding developed between two individuals through frequent interpersonal and enjoyable interactions across different settings [10] - [13]. When it is applied to a learning environment, whether in a presentation, workshop, or a lecture, "being able to establish rapport" is one of the seven essential abilities of an effective presenter, whom then "opens the door and invites learning" [14].

Numerous studies have examined student-professor rapport in non- science and engineering undergraduate programs, and its impact on various student outcomes including student learning, engagement, motivation, grades [4], [15] - [20], and attentiveness and studying efforts for the course [9], [15], [19]. Students were less likely to miss class when they experienced rapport with their professors [16]. It is safe to argue that class attendance as a critical component of learning and success [21]; further, it is known that it can be promoted by establishing rapport with students [16], [19]. Student-instructor rapport is also related to, and a predictor of, expected and actual grades [15], [16]. By establishing rapport, professors convey confidence in their students' ability to do well in the course [16]. This student-centered and growth-mind set approach engraved in rapport translate into greater intrinsic motivation and therefore higher student achievement [22], [16] .

Students also recognize the value of rapport, as they report rapport to be a key component of an effective professor [16], [24], [25]. This component can be improved by being encouraging, getting to know students, and maintaining frequent contact [15].

Knowing that rapport contributes to student attendance, learning, grades, intrinsic motivation, engagement, and degree completion, and that rapport can be modified through instructor behaviors, we sought to identify the behaviors most relevant to students in the science and engineering disciplines.

1.3: Hypothesis

Based on these collective findings, we sought to explore the faculty behaviors that have the highest potential for impact on student-instructor rapport. Further, we hypothesize that, within the science and engineering disciplines, there may exist differences in the perception of instructor behaviors that influence rapport depending on a) program of study, b) year of study, and c) gender. Therefore, the specific goals of this research project are to answer the following research questions: 1) What are the top quartile behaviors that establish positive rapport between engineering professors and engineering students; 2) Are there preferential differences for faculty behaviors between a) different engineering programs, b) the different years of student progression, or c) male and female students?

Existing studies in the engineering classroom noted the importance of faculty interactions but fall short of identifying if there are differences in level of rapport across grade levels. To the best of our knowledge, this work is the first in the field to specifically look at multiple engineering programs to identify the level of rapport across grade level, and to explicitly look at instructors' rapport building behaviors with an intention to develop a faculty training. We will broaden our impact by training engineering faculty on best practices that promote rapport between students and professors to tackle the difficulties of students' professional formation of engineering identity, first at our local institution, and later through publication of key findings from those efforts. This paper presents the results of the investigation focused on the student-instructor rapport building behaviors.

2: Methods

Students from multiple disciplines in an engineering college were surveyed online and asked to rank their perceptions of faculty behaviors that best establish rapport with themselves. The participating students were recruited using a college-wide all-student Listserv, and were reminded of the survey two weeks after the original notification. The survey asked students to self-identify their program of study, year of study (including graduate student status), and gender (Appendix A). The survey then asked fifteen questions about faculty behaviors that influence student-instructor rapport. These questions were derived from literature, which investigated student-instructor rapport in other disciplines. Participants selected responses using a five-point likert scale that ranged from "Strongly Disagree" to "Strongly Agree" for each statement of "When professors …"

Relative representation of each program of study, year of study, and gender was calculated and compared with the representative ratios for the university's college of engineering. Response groups that had low representation, less than or equal to two responding participants, were excluded in subgroup analyses.

Responses were then sorted by the descriptors, grouping those responses by program of study, year of study, gender, and combined program-year of study. Overall responses for all students were also calculated, as well as a normalized and unbiased response that controlled for differences in program of study response group sizes. To normalize, the mean response from each of the seven programs were then averaged together, giving equal one-seventh weight to each program of study.

Response categories of "Strongly Disagree," "Disagree," "Neutral," "Agree," and "Strongly Agree" were assigned corresponding ordinal ranks of one through five respectively. The likert value responses were averaged for these groups in order to represent a "general consensus" response. Mean likert responses near one for any given question reflect a strong disagreement that the given behavior is an important factor for student-instructor rapport, while mean responses near five indicate a strong agreement that the behavior is an important factor for student-instructor rapport. Median was not calculated, as the median of five categorical values obscures small differences in response. Likewise, standard deviation was not calculated for these

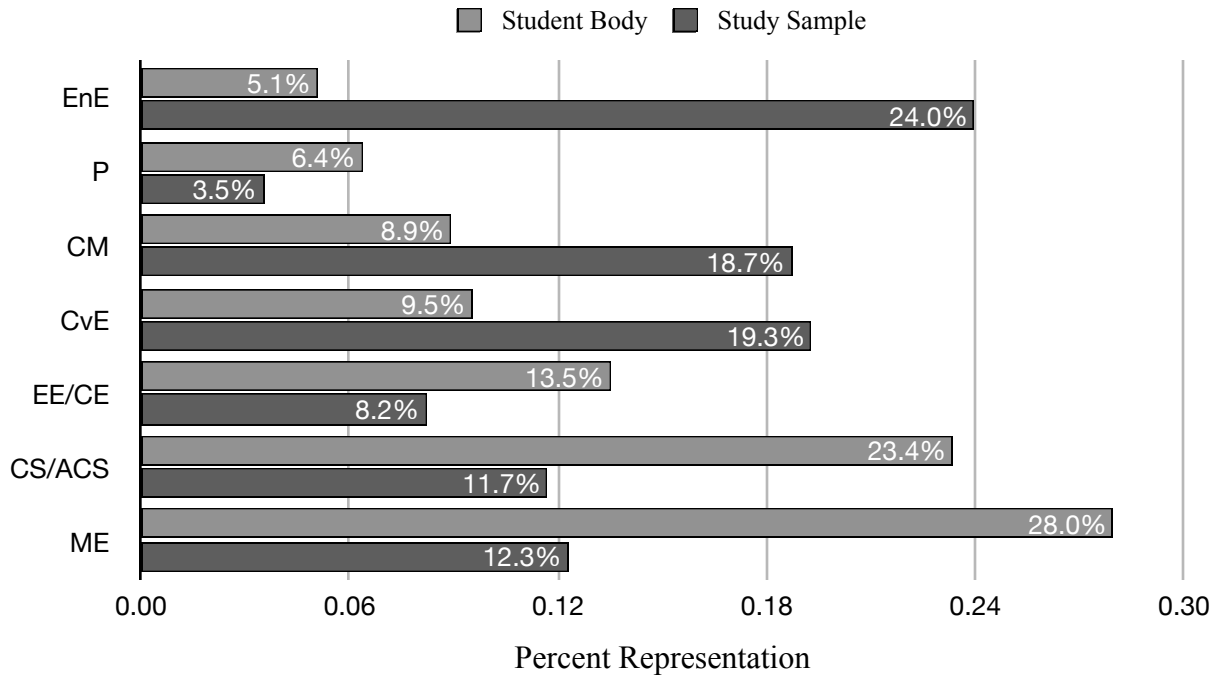

Figure 1: Shown here is the relative representation of students in the surveyed college, and the relative representation of students that responded to the survey. Disciplines represented include Environmental Engineering (EnE), Physics (P), Construction Management (CM), Civil Engineering (CvE), Electrical Engineering and Computer Engineering (EE/CE), Computer Science and Applied Computer Science (CS/ACS), and Mechanical Engineering (ME), and are shown in order of study body representation.

responses, given that standard deviation is not an appropriate mechanism of reflect measure spread for ordinal ranked categorical data. A histogram was created to aid in understanding the skew and spread of responses to each question.

Quartiles were calculated for each question. With limited time and other resources, faculty aren't necessarily able to increase efforts in all behaviors listed. Thus, prioritization of the key factors may be a valuable approach to improving rapport. Questions identifying top quartile response have been selected as areas of faculty behavior that should be considered for such focus.

3: Results

The college of engineering study body was approximately 2600 students in size. From these 2600 students, 171 students responded to the survey. Figure 1 shows the relative percentage of the student body for each program of study, and the percentage of student response from these programs. As can be seen, Mechanical Engineering is the largest study body in this college of engineering, and is represents approximately one of eight of the responses in this study, a representation ratio seen across most of the programs surveyed. Environmental Engineering and Physics are two exceptions to this trend. Environmental Engineering has the smallest body of

student representation, but also had the highest representation in this survey. Physics is the second smallest program of study, and also saw the smallest relative representation in the survey.

In the college, and across disciplines, females represent approximately 19.6% of the student body, 80.4% were male, and less than one percent of the student body have not identified with one of these genders. Response rates differed in that 40.5% of respondents were female, 58.3% were male, and 1.2% of the students preferred not to respond to this question. Freshman, sophomores, juniors, and seniors represent 28.5%, 21%, 19.8%, and 30.7% percent of the undergraduate study body across disciplines. This is similar to that seen in the survey responses, with 13.5%, 30.7%, 29.4%, and 26.4% percent response representation respectively across year of study.

Shown in Figure 2 are the net responses for all questions, across all student respondents. Notably, no questions elicited more than ten "Strongly Disagree" responses and most questions received more "Strongly Agree" responses than other response types. Four questions had more "Agree" than "Strongly Agree" responses, and one had an equal number of "Agree" and "Strongly Agree" responses.

Looking at top quartile responses, the following was found for each group. Groups considered include a) the entire group, b) the entire group and normalized for response rate, c) each program of study, d) year of study, e) gender, and f) combined program and year of study. Questions and a corresponding question keyword are shown in Figure 2.

3.1 The Entire Group

The majority of the responses were in the range of "Strongly Agree", which tells us that the students found all behaviors to be relevant to student-instructor rapport. The quartile analysis revealed that there are four "top" behaviors that impact student-faculty rapport. In order, these are "When professors are respectful" (respect, mean likert response 4.75), "When professors keep up with his/her email" (email, 4.67), "When professors use relevant class examples" (examples, 4.65), and "When professors are enthusiastic" (enthusiasm, 4.65).

Normalizing for response representation, only three behaviors emerge in the top quartile; "When professors are respectful" (respect, 4.73), "When professors keep up with their email" (email, 4.67), "When professors use relevant examples" (examples, 4.63).

3.2 Between Programs of Study

Top quartile behaviors for each program of study are shown in Table 1. This represents all years of study for each of these programs. Graduate students from the Environmental and Civil Engineering programs responded to this survey and are included in this analysis. An ANOVA was used to evaluate differences in ratings between the different disciplines. This analysis did not reveal a statistical difference across all groups.

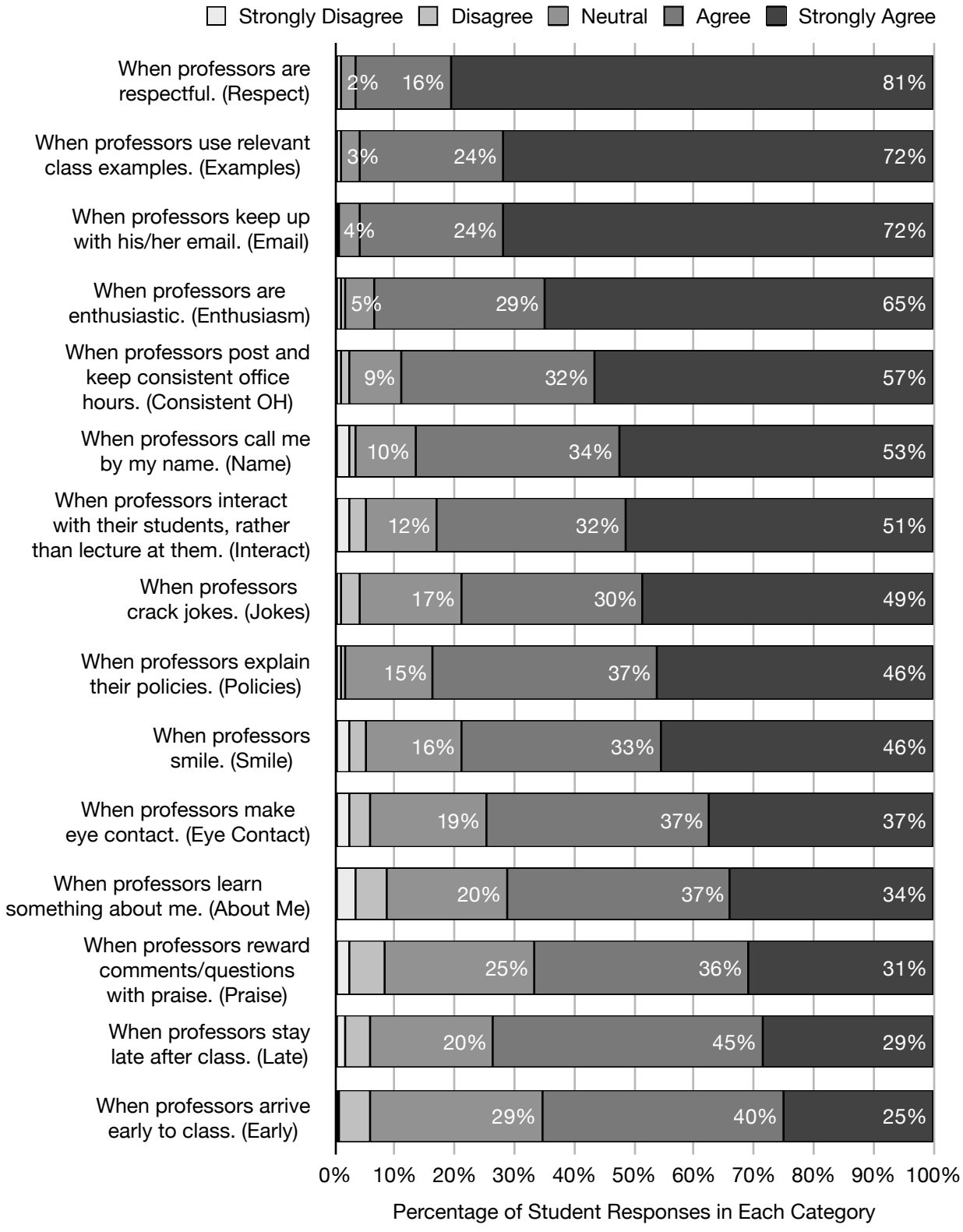

Figure 2: Shown here are the relative responses of "Strongly Disagree" to "Strongly Agree" for each of the questions asked in the survey. This includes all respondent students in raw form across all programs of study, years of study, and genders, and is ordered in decreasing levels of "Strongly Agree."

Table 1: Top quartile faculty behaviors, as stratified by program of study.

Ranking	EnE	CvE	CM	EE / CE	CS / ACS	ME	P
1	Respect (4.93)	Respect (4.73)	Respect & Email (4.72)	Email (4.71)	Respect (4.75)	Email (4.71)	Respect (4.83)
2	Examples (4.91)	Enthusiasm (4.67)	Examples & Enthusiasm (4.59)	Respect & Examples (4.64)	Email (4.60)	Examples (4.67)	Email, Examples, & Consistent OH (4.67)
3	Enthusiasm (4.78)	Email (4.58)		Policies (4.43)	Consistent OH (4.55)	Respect (4.48)	
4	Email (4.69)	Smile (4.48)			Examples (4.50)	Consistent OH (4.33)	

Respect: "When professors are respectful."
Examples: "When professors use relevant class examples."
Enthusiasm: "When professors are enthusiastic."
Email: "When professors keep up with his/her email."
Smile: "When professors smile."
Policies: "When professor explain their policies."
Consistent OH: "When professors post and keep consistent office hours."

Table 2: Top quartile faculty behaviors, as stratified by year of study.

Ranking	Freshmen	Sophomore	Junior	Senior	Graduate
1	Respect (4.80)	Email (4.88)	Respect (4.67)	Respect (4.77)	Examples (4.88)
2	Name (4.61)	Respect (4.78)	Email (4.66)	Email (4.58)	Respect & Enthusiasm (4.75)
3	Examples (4.58)	Examples (4.76)	Examples & Enthusiasm (4.52)	Examples (4.57)	Email (4.50)
4	Email (4.54)	Consistent OH (4.57)	*Consistent OH (4.49)*	Consistent OH (4.42)	*Interact, Name, Smile, & Consistent OH (4.25)*
5+	*Interact & Enthusiasm (4.35)*	*Enthusiasm (4.55)*		*Enthusiasm (4.36)*	

Italic lettering here reflects the top behavior in the second quartile.
Interact: "When professors interact with their students, rather than lecture at them."
The arrows here reflect changes in the student rating of each faculty behavior. The darker, larger arrow reflects the consistently highest rated behavior. The lighter, mid-weight arrow represents the consistently second highest rated behavior. Finally, the lightest, smallest weight arrow represents the third highest rated behavior. Not reflected, but seen in this table, are behaviors which demonstrate varying priority from the students as a function of academic year. For example, being known by name is important for freshman and graduate students, but does not present as a top quartile behavior in sophomore, junior, or senior students.

3.3 Between Years of Study

To answer the question of, if student academic progress status changes the student perception of what faculty behaviors contribute to student-instructor rapport, all students were grouped by year of study. This is shown in Table 2.

Table 3: Top quartile faculty behaviors, as stratified by gender.

Ranking	Female	Male
1	Respect (4.81)	Respect (4.71)
2	Email (4.77)	Email (4.61)
3	Examples (4.74)	Examples (4.59)
4	Enthusiasm (4.59) & Consistent OH (4.59)	Enthusiasm (4.54)

Enthusiasm and Consistent Office Hours were equally ranked by female respondents. All other behaviors were equally rated between female and male students.

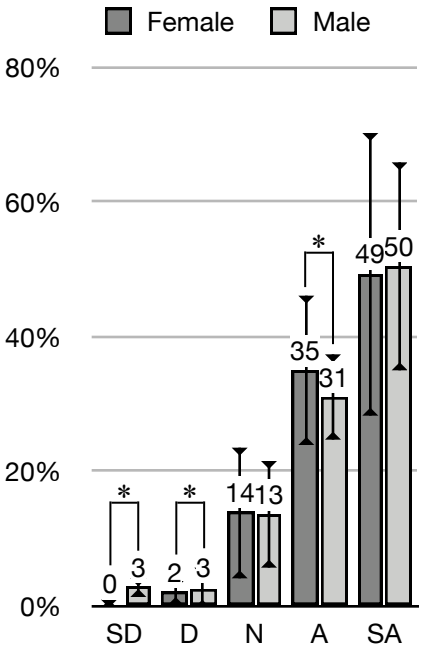

Figure 3: Shown here is the relative distribution of Strongly Disagree (SD) to Strongly Agree (SA) responses across all questions for female and male students. Numbers above each bar reflect the percentage of responses for each of the SD-SA categories. Error bars represent the variance (in standard deviation) of responses for each category and gender. Statistically significant differences are represented with an *.

3.4 Between Genders

Across all program and years of study, students were grouped by gender to identify gender specific influence in perceptions of faculty behaviors that build rapport. Shown in Table 3, the ranking between genders was exceptionally consistent.

4. Discussion of the Results

As seen above, regardless of how the responses are stratified, some behaviors are consistently identified by the students as determining, top quartile behaviors: “When professors are respectful,” “When professors keep up with his/her email,” and “When professors use relevant class examples.”

4.1 The Entire Group

Whether “Agree” or “Strongly Agree,” these positive responses combined constitute 97-94% of all responses in the top quartile behaviors. The next three quartiles received 89-65% “Agree” and “Strongly Agree” responses. This demonstrates that the top behaviors are clearly and strongly valued by the vast majority of students. Regardless of a student’s exact engineering program of study, instructors looking to build rapport should consider respect, email, relevant examples, and enthusiasm as key factors to leverage.

4.2 Between Programs of Study

As shown in the results and Table 1, there are several interesting differences between the various disciplines. This may reflect discipline culture differences, expectations of the students, or even differences in the instructors of those disciplines. For example, Electrical / Computer Engineering (EE/CE) and Mechanical Engineering (ME) students both rank “Email” higher than “Respect,” while the other disciplines all rank “Respect” as the top behavior. This suggests that students in these disciplines feel communication is more important than reverence in building a

harmonious student-faculty relationship. It is unclear if this reflects differences in communication of instructors between EE/CE/ME and the other disciplines, or if this may reflect differences in the expectations of the students between these disciplines.

Likewise, “When professors use relevant class examples” was in the top quartile of response for all programs of study except Civil Engineering (CvE). CvE is a discipline that students are exposed to real world examples every day. Assuming then that CvE students capitalize on this exposure, “relevant examples” may be inferred, and thus not a behavior that these students think about directly impacting rapport. Interestingly, CvE students were the only group that listed “Smile” in the top quartile. Yet it is unrealistic to think that CvE instructors smile any more, or less, than other discipline instructors; this may indicate other social or core value differences between CvE and other discipline students.

“When professors post and keep consistent office hours” came up in the top quartile for Computer / Applied Computer Science (CS/ACS), ME, and Physics. These students might prefer out-of-class clarification of abstract or otherwise challenging topics. This may be exemplified with in-class clarification for EE/CE students, whose responses for “Respect” and “Examples” are tied as the second most impactful instructor behaviors. Both suggest that additional learning modalities are important.

Another unique observation is the inclusion of “Policies” in the top quartile of EE/CE student respondents; no other disciplines reported “Policies” as a top quartile behavior. EE/CE students may have higher expectations of the clarity of “the class rules.”

Finally, “Enthusiasm” appeared in the first quartile for EnE, CvE, and CM respondents. These three disciplines are keenly related in the college of this study, suggesting that faculty may be exceptionally enthusiastic, enough so such that students recognize and appreciate such efforts.

4.3 Between Years of Study

It was interesting to notice that Freshmen uniquely lists “call by name” in their top quartile. These students, who recently started college, quite possibly feel like a number in a crowd of unfamiliar faces and thus realize the importance of their professors calling them by names more than other groups. Both sophomores and seniors listed “keeping consistent office hours” in their top quartile. One has to wonder if this suggests that sophomores are starting to recognize the value of meeting with their instructors. Likewise, seniors might recognize the significance of seeking help to ensure class success - most students have very few contingency options should they fail a required class in their last year or semester. Juniors listed enthusiasm as an important factor to establish rapport between themselves and their professors. Enthusiasm may support students through a “junior year slump.”

Most instructors might express the desire to address all of these program year specifics, across all phases of student progression, but these findings suggest that targeting specific behaviors might be a more efficient and effective approach. In short, Freshmen benefit more from being known

by name. Consistent office hours is key for students just starting into the harder topics of their program (generally sophomores) and for students who recognize the importance of finishing a class successfully to graduate (seniors). Juniors appreciate the contagious nature of the enthusiasm to infuse into their day in day out routine.

4.4 Between Genders

Females are, on average more biased than males, to agree that the behaviors listed support rapport building. As shown in Figure 3, this is demonstrated with the statistically significant difference in Agree (A) rates between the genders. The other side of this difference is reflected in the statistically significant difference in Strongly Disagree (SD) and Disagree (D) responses. Females provided a generally stronger agreement to the statements than males.

Both females and males listed “when professors are respectful” as their top choice among all the behaviors that establish rapport. They were in fact consistent for the next three choices as well for both genders. Within most behaviors, there was no gender difference between the behavior ranking, as shown in Table 3. Figure 3 shows that females provided a stronger agreement across all behaviors; while the rate of Strongly Agree (SA) is not statistically significantly different between genders, there does exist a statistical difference between genders in the rate of Agree (A) responses. This positive bias is mirrored in the tied mean response of the fourth ranked behaviors (Table 3) in the top quartile, the response of females that “keeping consistent office hours” is a top behavior in establishing rapport, possibly indicating that female students consider both written and in-person communication important in establishing rapport.

5. Conclusion

Respect for the students was first or second place behavior in all approaches of data stratification. Across program of study, and year of study, and gender, this behavior was clearly and consistently identified as important. Freshman stand out with the unique ranking of being known by name. In addition, females appreciate posted and consistently held office hours.

Our ultimate goal is to pave a path to engineering for more students from a broad range of backgrounds, interests, and experiences by increasing rapport between students and instructors. The results of this work reveal the best practices that particularly help students to establish student-instructor rapport. The best practices will be used to inform all engineering faculty at our own institution, so that they can strategically establish rapport in their classrooms. Establishing rapport in engineering classrooms will improve students’ attendance, learning, grades, intrinsic motivation, and engagement. We expect this is especially important for our underrepresented minority student groups. With the help of the training, we anticipate that establishing rapport will retain more minority students in engineering fields. Once the representation increases, it will be easier than ever to find role models for engineering students from various backgrounds, positively influencing lack of belongingness issues. It will be a positive feedback cycle of rapport creating student learning, success, motivation, and retention, and therefore increased representation in the field.

Using the results of this study, we can design interventions aimed at faculty member's ability to establish positive rapport, which in turn creates a respectful environment, and removes the barriers to cultivation of diverse student retention in engineering disciplines. The findings of this project could be disseminated to the engineering faculty through a blended training, online training coupled with a half day in-person workshop. This blended training format has been developed by Tingerthal and Ozis to model effective practices given the 'expert' nature of the participants and the limited time available, further information on this training format can be found in their paper [26]. The participants are expected to engage in two to three hours of online self-study, by reading the selected literature on rapport and professor behaviors, prior to a four-hour in-person structured seminar. The advantage of this format coupled with facilitators' experience could be used to engage in higher level discussions on the findings of our study. The half-day in-person seminar is structured to provide activities that would reinforce the topics explored within the online modules and would provide a discussion forum and networking opportunity for new instructors. The details about the activities are available upon request.

6. Challenge and Limitations

The challenges experienced during this work were related to the data collection, and the small sample size. One should be quick to note though, that it is known that all data based studies are constrained with the quality and quantity of collected data, and generalization beyond the context of the original study may violate context specific assumptions. The survey, as a Google form, was sent via email by using listservs, and the response rate was relatively low for some sub groups. A second reminder was sent to specific targeted groups as a follow up, after the first two weeks still had low correspondence.

Limitations to this study included that the Graduate students were only from Civil and Environmental Engineering Graduate program, therefore results may not be applicable for the graduate student body at large. Among undergraduate respondents, the largest portion (26.3%) were from Environmental Engineering Program. Also, our college is unique to have Applied Sciences combined with Engineering, we had 3.5% of the respondents from Physics.

7. Future Work

We plan to continue with additional surveys, and seek responses from broader student body to determine and rank the behaviors establishing rapport in engineering classrooms. In addition, our goal is to further develop the blended faculty professional development and educate our faculty on the behaviors that establish rapport. To understand the real impact on students, we will continue to study the instructor behavior, and student feedback correlating the impact of rapport on student resilience and retention in a longitudinal study.

It is important for us to hear students' perceptions as well. A future study will seek to understand how our students define "respect" as compared to how faculty define it.

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