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Perceptions of the Importance of Interpersonal Skills by Engineers, Students, and Faculty*

MORGAN GREEN
Department of Mechanical Engineering, Mississippi State University, Mississippi, United States of America.
E-mail: green@me.msstate.edu

ALTA KNIZLEY
Institute of Clean Energy Technology, Mississippi State University, Mississippi, United States of America.
E-mail: knizley@icet.msstate.edu

LESLEY STRAWDERMAN
Department of Industrial and Systems Engineering, Mississippi State University, Mississippi, United States of America.
E-mail: strawderman@ise.msstate.edu

Engineering undergraduates are expected have a base level of technical skills upon graduation. Teaching technical skills comes naturally to engineering programs as the conceptual understanding of the material forms the foundation of engineering ability. However, engineering graduates also are expected to have a base level of professional, or interpersonal, skills, which are more subjective in nature and do not have a standardized approach for teaching or assessing them at the undergraduate level. This work explored the perceptions held by engineering students, engineering faculty, and practicing engineers toward the importance of specific interpersonal skills. Eight interpersonal skills were investigated: collaboration, communication, ethical considerations, inclusivity, leadership, professional judgment, task management, and teamwork. Statistical analysis of survey data indicated that students, faculty, and practicing engineers have similar views of the importance of each of the eight professional skills. Results showed that student ratings of their peers' abilities align with the perceptions that practicing engineers have of student abilities. Peer and practicing engineer ratings were statistically significantly lower than student ratings of their own abilities. The discrepancies in perceptions of student ability show the subjective nature of interpersonal skills. Work to align these perceptions is needed to provide a more consistent assessment of interpersonal skills.

Keywords: interpersonal skills; communication; leadership; efficacy

1. Introduction

Across the nation, engineers go to work in environments where they must utilize interpersonal skills. Whether it is giving a presentation, working in a team, negotiating purchases, or sending a summary of a project, engineers are using a skillset outside of the typical "hard" technical skills that encompass an engineering curriculum. However, there is not a clear consensus among students, engineering faculty, and practicing engineers on what it means to be good at various interpersonal skills or how to properly assess them. According to current literature, there is a need to evaluate the current perceptions of the top-rated interpersonal skills of these constituents.

Numerous studies show that engineering employers are seeking to hire engineering graduates that demonstrate proficient interpersonal skills. Joachim et al. [1] and Skipper et al. [2] discussed the need for empathy and emotional intelligence. Pastel et al. [3] investigated team building. Many studies discuss the need for engineers to be proficient in interpersonal skills and propose strategies for improving these skills. Carter [4] looks at employer needs and student skill perception within a computer science framework. Results of this study are discussed in subsequent sections. Hynes and Swenson [5] look at incorporating more emphasis on soft skills required for engineering projects to enhance and diversify engineering recruitment and encourage engineering educators to focus on more humanistic components of engineering. Kumar and Hsiao [6] and Mohan et al. [7] both discuss the importance of developing interpersonal skills in engineering curriculum and give examples of pedagogy to address this deficiency. Pulko and Parik [8] and Rao [9] discuss specific techniques for teaching soft skills to engineering students, while Schulz [10] emphasizes the importance of training all college students in interpersonal skills.

These interpersonal skills include communication, initiative, teamwork, and organization, among others. Jahan et al. [11] discuss the push for improved educational practices in the areas of diversity, equity, and inclusion. As the engineering field becomes more global, proficiency in these skills

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will be paramount [2]. However, in many cases students are learning these skills after graduation. They learn "soft skills the hard way" on the job [6]. There is a need to find efficient ways to effectively teach these skills at the undergraduate level. Bordel et al. [12] outline their approach to accomplishing this task with communication. They employed various instructional tools, technologies, and strategies and found varying success with the different options based on the context of which they were utilized (i.e., course structure and method of instruction).

Additionally, there is not a clear consensus on the operational definitions of the skills, making fair and consistent assessment difficult [13, 14]. In their study, Boelt et al. [15] investigated teamwork and collaboration, finding some instances of alignment in perceptions, but also finding that students used terms without clear operational definitions. Because of the subjective nature of interpersonal skills perceptions and assessment, a starting point in obtaining these operational definitions is investigating the current state of interpersonal skills abilities and perceptions for engineering students. Understanding that these current perceptions may be deep-rooted, initial work will investigate the possibility of slightly adjusting the perceptions of the constituents as opposed to aligning them to set of ideals that may not be close to current perceptions.

This study investigated faculty, practicing engineers, and student perceptions of the importance of, of student ability with, and of student education in various interpersonal skills. These results identified areas where goals and approaches to interpersonal skills education may need to be realigned.

2. Literature Review

2.1 Which Interpersonal Skills are the most Important to Employers?

Literature shows that interpersonal skills are necessary for engineering graduates, but there is less agreement on how those skills rank or, many times, even what to call them. To gather data on student perceptions of top interpersonal skills, a concise list is needed.

One study asked employers to list skills that they want in potential hires and to rate the importance of the skills on a scale of 1–5, with 1 being the lowest and 5 being the highest. The technical skills that were listed averaged an importance rating of 3.3, and the interpersonal skills that were listed averaged an importance rating of 4.5 [4]. If this statistic holds true for most STEM employers, then the need for curriculums that teach interpersonal skills is evident. In addition to employers asking for interpersonal skills, the skill sets as given by the engineering accreditation body ABET include interpersonal skills such as professional judgment, team work, leadership, collaboration, inclusivity, task management, ethical considerations, and communication [16]. Leadership and management positions in industry require a working knowledge and proper utilization of professional skills, and engineers may find themselves overlooked for these positions when compared to employees with degrees where teaching interpersonal skills is naturally a part of the curriculum, such as business and the social sciences [10].

Woods et al. created a survey that combined the skills listed most frequently in interpersonal skills literature. They took a list of twenty-three skills and asked employers (from all backgrounds, engineering included) to assign a level of importance to each skill and a frequency of use. They found that the ratings for importance and frequency were similar overall, so the top eleven skills given are a combination of the two ratings [17].

2.2 Perceptions of Practicing Engineers and Faculty

For a successful integration of interpersonal skills into a curriculum, constituents should have a similar understanding of the importance of developing these types of skills. These parties include students, faculty, and industry professionals. Carter provides data that shows employers', students', and faculty's opinions towards interpersonal skills: for the employers' data, job descriptions for postings for software engineers on Monster.com were evaluated. Out of the 50 descriptions evaluated, 43 of them listed various interpersonal skills as requirements. The top four skills were written communication (34 responses), verbal communication, teamwork, and self-motivation/learning [4]. Hirudayaraj surveyed over 450 practicing engineers and found that the rated importance outranked the rated proficiency for 24 of the 26 interpersonal skills surveyed. ANOVA showed there was a statistically significant difference in the means of importance and proficiency for the 24 skills where importance was rated higher ($p < 0.001$ for 23, $p < 0.05$ for 1). The two skills where proficiency was rated higher than importance were global and cultural awareness and social responsibility [18].

Interviews conducted with faculty in a technical public university show a faculty awareness for the necessity of developing interpersonal skills [19]. The faculty gave four skills categories in which they believe students should be competent by graduation: technical, interpersonal, self-regulatory, and social responsibility.

Kabicher et al. administered a survey to investigate the importance that employers and faculty

placed on various interpersonal skills. This study did show similar perceptions by the two groups of the skills; however, this study is limited in that the number of surveys completed by employers and by faculty were 35 and 17, respectively [20]. A greater sample size is needed to more adequately compare perceptions of the constituents.

2.3 Which Interpersonal Skills are Students Utilizing?

In their study, Picard et al. administered a survey to students completing a team project in an undergraduate engineering class and in a graduate engineering class [21]. The results of this study show that in team projects, students are utilizing logistical skills to organize and complete tasks. The team project also, on average, improved interpersonal skill levels of the students.

2.4 Perceptions of Students

To evaluate students' opinions of interpersonal skills, students at Point Loma Nazarene University (PLNU) were given ten interpersonal skills and asked to rank their importance on a 1–5 scale (with 5 being the highest). The responses (27 students) for every skill averaged over 2.5, with four skills averaging over 4. Those top four skills were communication, teamwork, professional attitude, and self-motivation/learning. Work across disciplines, passion for work, efficient/deadline conscious, problem solving/creativity, and organization were all at 3 or above but less than 4. The only skill rated below 3 was leadership [4].

A study exploring student perceptions toward top-rated interpersonal skills would close gaps in literature. There is a need to see how students perceive the importance of various interpersonal skills as well as investigate what environment has fostered the growth (or lack thereof) of interpersonal skills thus far in students' lives.

2.5 Summary

Overall, these studies show that students, faculty, and practicing engineers alike understand the need for employees to be proficient in interpersonal skills, primarily communication, teamwork, and initiative. The skills studied in literature are all valid interpersonal skills, and many studies investigate the same or similar ones. However, investigating skills directly tied to Accreditation Board for Engineering and Technology (ABET) Student Outcomes [16] would be beneficial to the research area. Literature is lacking a comparison of the perceptions of students, faculty, and practicing engineers in the same study. Studies have investigated the perceptions of the groups individually and paired with one of the other groups $\geq$, but such studies do not allow a direct comparison between the three groups' perceptions. The viewpoint of all three groups is necessary for building a holistic picture. Once an understanding of current perceptions is understood, approaches can be created and perfected to align these perceptions.

3. Methods

3.1 Design

The study utilized surveys to evaluate the perceptions of the importance of various interpersonal skills as perceived by engineering faculty, by practicing engineers, and by students' views of themselves as well as their peers. Additionally, perceptions of engineering student ability with these same interpersonal skills were evaluated by the same groups.

3.2 Participants

The students in the study were undergraduate engineering students currently enrolled in ABET accredited programs in the Southeastern United States of America. The faculty in the study were recruited from the same programs as the students. Practicing engineers were recruited from companies that hire students from these programs. Table 1 shows the distribution of undergraduate majors for respondents. For the student respondents (n = 146), 13.7% were freshmen, 14.4% sophomore, 26.0% junior, and 45.9% senior classification. Practicing engineers (n = 75) represented 33 unique industries,

Table 1. Distribution of Undergraduate Majors of . . . Respondents

Major	Students (n = 146)	Faculty (n = 25)	Practicing Engineers (n = 75)
Aerospace engineering	12.3%	4.0%	2.7%
Biomedical/biological engineering	9.6%	16.0%	1.3%
Chemical engineering	9.6%	24.0%	13.3%
Civil/environmental engineering	14.4%	8.0%	5.3%
Computer/software engineering	7.5%	8.0%	1.3%
Electrical engineering	6.8%	8.0%	1.3%
Industrial/systems engineering	4.1%	4.0%	6.7%
Mechanical engineering	32.9%	12.0%	68.0%
Other engineering	2.7%	12.0%	0.0%

with the most common being defense (10.7%), automotive (9.3%), aerospace (8.0%), manufacturing (8.0%), and utilities (6.7%).

3.3 Survey Instrument

The survey instrument aimed to capture perceptions of the importance of and student ability with a variety of interpersonal skills; the eight skills listed in the survey were (i) collaboration, (ii) communication, (iii) ethical considerations, (iv) inclusivity, (v) leadership, (vi) professional judgment, (vii) task management, and (viii) teamwork. The list of interpersonal skills were taken from the ABET Criterion 3: Student Outcomes [16]. The list of interpersonal skills presented by Woods et al. [17] and Picard et al. [21] were cross-referenced with the ABET Student Outcomes to create the list of eight interpersonal skills included in this study. The seven ABET Student Outcomes are listed below. The interpersonal skill(s) contributing to the formulation of outcomes are listed below the outcome as relevant.

1. An ability to identity, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.
   (a) Ethical considerations (iii); professional judgment (vi).
3. An ability to communicate effectively with a range of audiences.
   (a) Communication (ii).
4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.
   (a) Ethical considerations (iii); professional judgment (vi).
5. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.
   (a) Collaboration (i); inclusivity (iv); leadership (v); task management (vii); teamwork (viii); communication (ii).
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.
   (a) Professional judgment (vi).
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

Participants were asked to rate the importance of and the current engineering students'/recent graduates' skills with the eight interpersonal skills via a slider scale. Participants responded to each question along the scale, and while no numerical distinctions were provided to participants, the scale ranged from 0 to 100. Appropriate anchors for the question were provided. This scale is more akin to a continuous scale than typical Likert scales, allowing for greater expression from participants for the responses. Definitions for the interpersonal skills were not provided to the participants, as providing definitions might affect the participants' perceptions of the professional skills.

3.4 Analysis

To complete analysis, Statistical Package for Social Sciences (SPSS) [22] software was used, with repeated-measures ANOVA with subsequent Tukey post-hoc tests being conducted.

4. Results

4.1 Importance

4.1.1 Comparing Mean Ratings Across Groups

Fig. 1 provides a visualization of how each group rated the importance of each interpersonal skill on average. Standard error is indicated for each mean rating.

One-way ANOVA was completed to compare faculty, practicing engineers, and student perceptions of the importance of each interpersonal skill. Results showed no statistically significant difference between the mean ratings for the importance of the interpersonal skills across each group. The numerical results of the analysis along with the means standard deviations for each group and interpersonal skill are shown in Table 2. Bolded numbers in the table indicate the highest mean for each skill. The highest skill within a group is underlined. For all groups, communication was the highest rated skill.

4.1.2 Comparing Mean Ratings for Interpersonal Skills Within Each Group

One-way repeated-measures ANOVA was completed to compare mean rated importance for each interpersonal skill within each group. There was a statistically significant difference in ratings of importance for the interpersonal skills for faculty [$F(7, 192) = 9.44$, $p < 0.001$], practicing engineers [$F(7, 573) = 22.08$, $p < 0.001$], and students [$F(7, 1125) = 24.90$, $p < 0.001$].

The eta squared value for faculty ($\eta^2 = 26\%$) and practicing engineers ($\eta^2 = 21\%$) show a large effect,

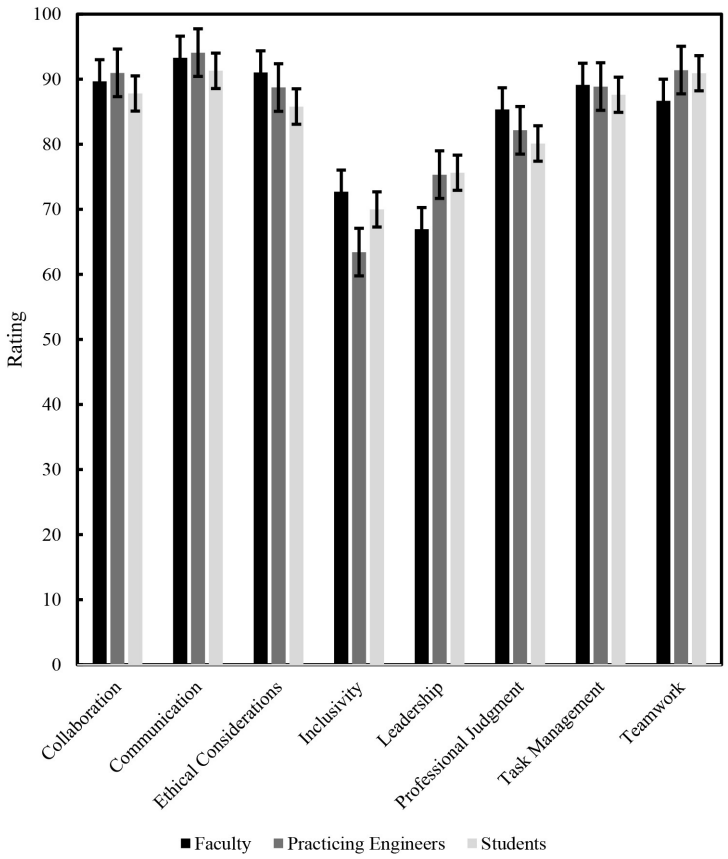

Fig. 1. Mean Rated Importance for Each Interpersonal Skill by Group.

Table 2. Means, Standard Deviations, and One-Way ANOVA of Group and Mean Rated Importance for Each Interpersonal Skill

Skill	Faculty			Practicing engineers			Students			F	η^2
	N	M	SD	N	M	SD	N	M	SD		
Collaboration	25	89.68	13.32	75	**90.96**	12.22	144	87.80	16.28	1.15	0.009
Communication	25	93.28	10.84	70	**94.07**	11.20	135	91.28	12.46	1.35	0.012
Ethical Considerations	25	**91.04**	11.38	70	88.71	19.67	136	85.79	18.21	1.22	0.011
Inclusivity	25	**72.72**	23.29	69	63.42	31.73	143	69.99	28.08	1.53	0.013
Leadership	25	66.96	18.82	69	75.32	19.27	145	**75.61**	19.93	2.14	0.017
Professional Judgment	25	**85.36**	14.08	69	82.15	18.55	145	80.11	17.05	1.13	0.009
Task Management	25	86.68	13.92	72	**91.39**	11.08	140	90.90	12.05	1.54	0.013
Teamwork	25	**89.12**	12.80	75	88.85	16.46	145	87.60	17.18	0.19	0.002
Mean	25	84.36	14.81	71	84.36	17.52	142	83.64	17.66		

* $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$. *Note.* Highest mean for each skill is bolded. Highest skill within a group is underlined.

Table 3. Subsets for Mean Ratings of Importance for Faculty

Interpersonal Skill	N	Subset 1	Subset 2	Subset 3
Leadership	25	66.96		
Inclusivity	25	72.72	72.72	
Professional Judgment	25		85.36	85.36
Task Management	25			86.68
Teamwork	25			89.12
Collaboration	25			89.68
Ethical Considerations	25			91.04
Communication	25			93.28

Table 4. Subsets for Mean Ratings of Importance for Practicing Engineers

Interpersonal Skill	N	Subset 1	Subset 2	Subset 3	Subset 4
Inclusivity	69	63.42			
Leadership	75		75.32		
Professional Judgment	75		82.15	82.15	
Ethical Considerations	70			88.71	88.71
Teamwork	75			88.85	88.85
Collaboration	75			90.96	90.96
Task Management	72			91.39	91.39
Communication	70				94.07

Table 5. Subsets for Mean Ratings of Importance for Students

Interpersonal Skill	N	Subset 1	Subset 2	Subset 3	Subset 4
Inclusivity	143	69.99			
Leadership	75	75.61	75.61		
Professional Judgment	75		80.11	80.11	
Ethical Considerations	70			85.79	85.79
Teamwork	75				87.60
Collaboration	75				87.80
Task Management	72				90.90
Communication	70				91.28

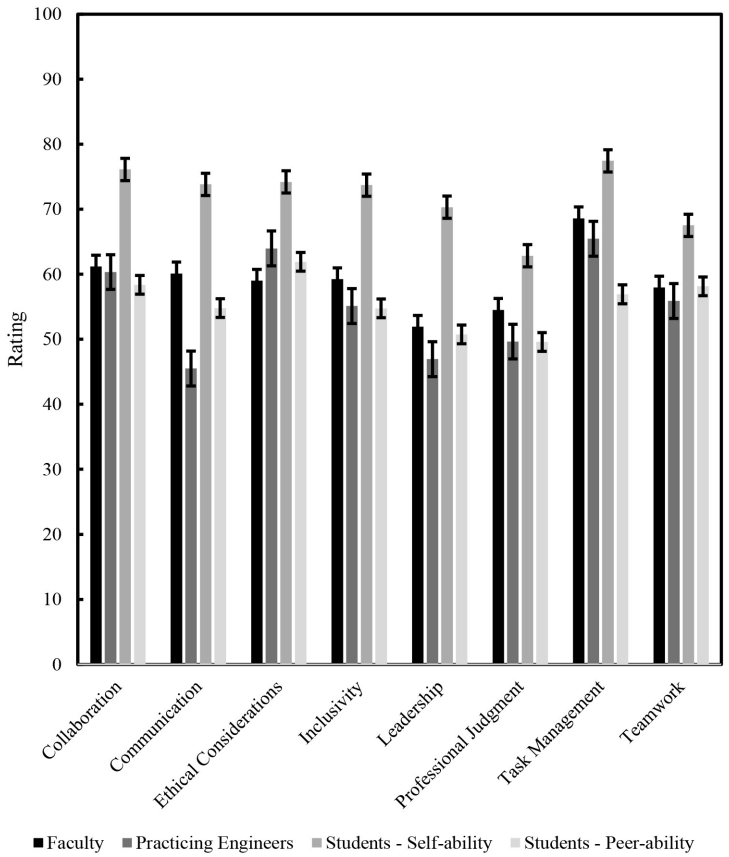

Fig. 2. Mean Rated Student Ability for Each Interpersonal skill by Group.

showing that the particular interpersonal skill accounts for 26% and 21%, respectively, of the variability in mean ratings for importance. For students, the eta squared was calculated to be 13%, which is a medium effect. Tukey post-hoc analysis shows interactions between significantly different skills for each group and provided a summary table for each group with subsets created

Table 6. Means, Standard Deviations, and One-Way Analyses of Variance of Group and Rated Student Ability for Each Interpersonal skill

Skill	Faculty			Practicing engineers			Student self-ability			Student peer-ability			F	η^2
	N	M	SD	N	M	SD	N	M	SD	N	M	SD		
Collaboration	25	61.20	16.44	75	60.33	19.86	145	**76.11**	17.29	145	58.37	18.86	25.91***	0.17
Communication	25	60.12	22.27	70	45.50	21.77	135	**73.81**	19.11	135	54.79	19.57	36.63***	0.23
Ethical Considerations	25	59.00	22.77	70	63.97	22.92	136	**74.19**	20.64	136	61.90	22.01	9.01***	0.07
Inclusivity	25	59.24	23.29	69	55.12	23.84	143	**73.71**	22.41	143	54.75	22.63	19.57***	0.14
Leadership	25	51.92	16.93	69	46.95	17.48	145	**70.31**	20.13	145	50.74	18.84	36.51***	0.22
Professional Judgment	25	54.52	19.86	69	49.64	17.65	144	**62.84**	18.72	144	49.60	16.21	16.19***	0.11
Task Management	25	57.96	17.69	75	55.89	21.70	139	**67.52**	22.37	140	58.14	19.66	29.68***	0.19
Teamwork	25	68.60	13.97	72	65.45	18.65	145	**77.44**	19.23	145	56.91	18.61	6.93***	0.05
Mean	25	59.07	19.15	71	55.36	20.48	142	71.99	19.99	142	55.65	19.55		

*** $p < 0.001$. *Note.* Highest mean for each skill is bolded. Highest skill within a group is underlined.

as a result of the post-hoc analysis. Subsets are shown for each ANOVA test. One or more interpersonal skills listed within the same subset were not determined to have no statistically significant difference in their means. Interpersonal skills not found within the same subset were determined to have a statistically significant difference in means. The subsets for faculty, practicing engineers, and students are shown in Tables 3, 4, and 5, respectively. In the tables, N represents the sample size.

4.2 Student Ability

4.2.1 Comparing Mean Ratings Across Groups

Fig. 2 provides a visualization of how each group rated student ability of each interpersonal skill on average. Standard error is indicated for all mean ratings. Both self-ability and peer-ability ratings were included for the students.

One-way repeated-measures ANOVA was completed to compare faculty, practicing engineers, and student perceptions (self and peer) of abilities of students for each interpersonal skill. Results showed a statistically significant difference between the mean ratings for the student ability with the interpersonal skills across each group. The numerical results of the analysis along with the means and standard deviations for each group and interpersonal skill are shown in Table 6. Bolded numbers in the table indicate the highest mean for each skill. It is seen that for every skill, student self-ability had the highest mean of the four groups. The highest skill within a group is underlined. For all groups but student peer-ability, teamwork had the highest mean. For student peer-ability, ethical considerations had the highest mean.

5. Discussion

5.1 Importance

5.1.1 Comparing Mean Ratings Across Groups

There is no statistically significant difference in the ratings of importance for all skills between students, faculty, and practicing engineers. All three groups have a comparable perception of the importance of each of the interpersonal skills. Thus, the null hypothesis was not rejected for any interpersonal skill. In fact, from highest to lowest mean for the skill, the practicing engineers and students had the same order of skills. For the faculty, two pairs of skills were switched compared to the rankings of students and practicing engineers. On average, all three groups rated communication as the most important interpersonal skill. Each group had mean ratings for all interpersonal skills except inclusivity and leadership at 80.00 or higher.

These results agree with those presented by Carter [4]. Top skills requested by employers, when mapped to the eight interpersonal skills used in this study, were communication and teamwork. When asked to rate the importance of various interpersonal skills on a scale of 1 to 5, students had communication and teamwork rated highly. In this study, communication had the highest mean rating of importance for both practicing engineers and students, and teamwork had a high rating as well.

5.1.2 Comparing Mean Ratings for Interpersonal Skills Within Each Group

There were some statistically significant differences when comparing mean ratings of the interpersonal skills within each group. These results show some subtleties in how each group perceives the interpersonal skills. Future work could explore the source of the slight differences. All three groups have communication, task management, collaboration, teamwork, and ethical considerations in the top subset of skills. Thus, these can be considered the most important interpersonal skills.

This overall alignment in perception of the importance of the interpersonal skills is promising when it comes to interpersonal skills education for engineers. Educational practices can then focus on ensuring students have high ability with the per-

ceived most important skills; notably communication, task management, collaboration, teamwork, and ethical considerations.

5.2 Student Ability

5.2.1 Comparing Mean Ratings Across Groups

There is a statistically significant difference in the mean ratings of student ability for one or more groups for each interpersonal skill ($p < 0.001$). Overall, all of the mean ratings that students assigned to their own ability except for one skill (professional judgment) are numerically higher than the highest mean rating of the practicing engineers.

Communication and leadership had the highest effect sizes ($\eta^2 = 23\%$ and 22%, respectively), which was expected because of the clear discrepancy in student ability for the skills. Both of these skills had the largest differences between the highest and lowest mean rating between the groups. Other interpersonal skills with high effect sizes were task management ($\eta^2 = 19\%$), collaboration ($\eta^2 = 17\%$), and inclusivity ($\eta^2 = 14\%$).

Post-hoc analyses showed that student self-ability had a statistically significant, positive mean difference between every group for every interpersonal skill except with faculty for professional judgment, task management, and teamwork. Thus, it can be said that students think more highly of their own abilities than they think of their peers' abilities to a statistically significant level for every interpersonal skill. Similarly, students think more highly of their own abilities than practicing engineers think of the students' abilities to a statistically significant level for every interpersonal skill. The quality of the students who responded to the survey may have an effect on these results. Students and practicing engineers were asked to rate the average engineering student's ability with each interpersonal skill, thus the similarities between the peer-ability and practicing engineer groups are encouraging (only two interpersonal skills, communication and teamwork, had mean differences at a statistically significant level). However, the difference between student self- and peer-ability perceptions warrants an explanation, and the authors attribute this difference to illusory superiority. The quality of student cannot be determined, but this consideration should still be made when looking at the results of the analysis.

Even though all groups agree on the importance of communication, they disagree on how well students execute the skill. The only pair where the null hypothesis (means are the same) was not rejected was faculty and student peer-ability. Three groups have distinct perceptions of student ability with communication: high, student self-ability; medium, faculty; and low, practicing engineers.

The results of the ANOVA both agree and disagree with those presented by Hirudayaraj et al [18]. In Hirundayaraj et al.'s survey to practicing engineers, the mean rating for importance was higher than that of rated proficiency to statistically significant difference for 24 of the 26 skills provided. In the work presented in this paper, for all but the comparison of student rated importance and self-ability for inclusivity, the mean rating for importance was higher than the mean rating for student ability for every interpersonal skill and group.

Results show that students likely think highly of their own abilities with interpersonal skills, but the perception is perhaps misguided. For every interpersonal skill, the highest mean rating was for student self-ability. For all but one interpersonal skill (ethical considerations), there was a significant difference in mean rated student ability for student self-ability and practicing engineers. A conclusion can be drawn that engineering students/graduates are likely entering the workforce with an inflated perception of their abilities with interpersonal skills despite the fact that both groups agree on the rated importance of the eight skills. Further studies could investigate if this inflated perception affects engineering students'/recent graduates' attitude toward training in these skills.

Student self-ability mean rated student skill was found to be significantly higher than those of student peer-ability for all interpersonal skills except teamwork. For all but one interpersonal skill (task management), there was a significant difference in mean rated student ability for student self-ability and faculty. A conclusion can be drawn that while faculty may believe students need more development in certain interpersonal skills, students may view themselves as proficient or better. This may lead to students not fully investing their time and efforts into assignments designed to give practice with interpersonal skills. Future work should focus on clear, objective definitions for what it means to be proficient at each interpersonal skill to avoid discrepancies and help curb illusory superiority. While this study doesn't investigate specific changes to be made in the classroom, the authors suggest varying delivery methods, report style, and peer-to-peer learning activities may enable improved skill retention and should be studied in future.

6. Limitations

The small sample size of faculty (25) when compared to practicing Engineers (75) and students (146) may have introduced unintended error.

While ANOVA does control for differences in sample size, that control is assuming that while small, the sample is representative of the population. It cannot be concluded that the sample of faculty is representative of the greater engineering faculty. Future work with a larger sample size of faculty may yield different conclusions.

A large portion of students and practicing engineers are either currently enrolled at or are alumni of the authors' institution.

The demographics do not include the respondent's years of experience in their position/field. Generational differences in the groups are not controlled for. For faculty, demographics do not include faculty rank. Additionally, it was not distinguished if faculty were primarily research- or teaching-focused. Faculty with a primary teaching appointment may have different perceptions than those with a higher research appointment.

7. Conclusions and Future Work

This work confirmed many anecdotal assumptions of the perceptions of interpersonal skills when it comes to faculty, practicing engineers, and students. While students thought highly of their own abilities, faculty and practicing engineers rated student abilities comparably between each other, with communication being the only interpersonal skill where the mean rated student ability was found to be significantly different between the two groups. For all but two interpersonal skills (ethical considerations and task management), student self-ability was significantly higher than both faculty and practicing engineers when it comes to perception of student ability with the interpersonal skills.

The alignment of the rated importance of the skills was a surprising result yet has positive implications on the potential to improve interpersonal skills education for engineering students. Future work should aim to clearly define what it means to be proficient at each of the interpersonal skills, which can potentially help align the student ability ratings. Clear definitions may lead to an increased and improved education of interpersonal skills at the university level.

Communication was rated on average as the most important skill on the list for all three groups (faculty, practicing engineers, and students), but it was not found to be significantly higher than all other interpersonal skills for any group. Regardless, there was not a significant difference found between each group's mean rating for communication, thus all have the same perception of importance of the skill. However, for student ability with communication, student rating for self-ability was significantly higher than the faculty rating, which was significantly higher than practicing engineers rating. There is a clear discrepancy in what the skill level of students is when it comes to communication. The agreement in importance of communication is a positive in addressing the differences in perceived student ability. All groups should likely be receptive to improved communication education, assuming they all think it is currently at a low level. Future work to improve interpersonal skills pedagogy in engineering should focus on communication, as the results show this to be an important skill that is falling short of its expected results.

The results of this study help to outline the next steps in interpersonal skills education of engineering students. First, standardization of definitions of the interpersonal skills and what "good, average, and bad" looks like can lead to changes in perceived student ability with the interpersonal skills. If all groups are assessing the student ability using the same metric, then a more accurate understanding can be achieved. From there, educators can take advantage of the aligned importance perceptions and work to ensure students have high ability in the most important interpersonal skills.

Another future area of expansion for this work is to compare perceptions of interpersonal skills to perceptions of technical skills. It is worth investigating if the magnitudes of the means for the perceptions of both importance and student ability with the skills change if the participants are also considering technical skills.

References

1. C. Skipper, L. Greenlee, J. Finch and K. Marley, Emotional Intelligence and Undergraduate Engineering Students, *Eng. Proj. Organ. J.*, **7**(1), 2017.
2. J. Walther, S. E. Miller and N. W. Sochacka, A Model of Empathy in Engineering as a Core Skill, Practice Orientation, and Professional Way of Being: A Model of Empathy in Engineering, *J. Eng. Educ.*, **106**(1), pp. 123–148, 2017.
3. R. Pastel, M. Seigel, W. Zhang and A. Mayer, Team Building in Multidisciplinary Client-Sponsored Project Courses, *ACM Trans. Comput. Educ.*, **15**(4), pp. 1–23, 2015.
4. L. Carter, Ideas for adding soft skills education to service learning and capstone courses for computer science students, in *Proceedings of the 42nd ACM technical symposium on Computer science education - SIGCSE '11*, Dallas, TX, USA: ACM Press, p. 517, 2011.
5. M. Hynes and J. Swenson, The Humanistic Side of Engineering: Considering Social Science and Humanities Dimensions of Engineering in Education and Research, *J. Pre-Coll. Eng. Educ. Res. J-PEER*, **3**(2), 2013.
6. S. Kumar and J. K. Hsiao, Engineers Learn 'Soft Skills the Hard Way': Planting a Seed of Leadership in Engineering Classes, *Leadersh. Manag. Eng.*, **7**(1), pp. 18–23, 2007.

7. A. Mohan, D. Merle, C. Jackson, J. Lannin and S. S. Nair, Professional Skills in the Engineering Curriculum, *IEEE Trans. Educ.*, **53**(4), pp. 562–571, 2010.
8. S. H. Pulko and S. Parikh, Teaching 'Soft' Skills to Engineers, *Int. J. Electr. Eng. Educ.*, **40**(4), pp. 243–254, 2003.
9. M. S. Rao, Enhancing employability in engineering and management students through soft skills, *Ind. Commer. Train.*, **46**(1), pp. 42–48, 2014.
10. B. Schulz, The importance of soft skills: Education beyond academic knowledge, *Journal of Language and Communication*, pp. 146–154, 2008.
11. K. Jahan, S. Farrell, H. Hartman and T. Forin, Integrating Inclusivity and Sustainability in Civil Engineering Courses, *Int. J. Eng. Educ.*, **38**(3), pp. 727–742, 2022.
12. B. Bordel, R. N. Alcarria and T. S. Robles, Assessing the Impact of Communication Instructional Tools and Strategies on the Students' Learning in the Context of Blended and Online Methodologies, *Int. J. Eng. Educ.*, **39**(4), pp. 1012–1034, 2023.
13. N. Sambamurthy and M. Cox, Developing a Behavior-Based Rubric for Assessing Professional Skills During Hiring, in *2016 ASEE Annual Conference & Exposition Proceedings*, New Orleans, Louisiana: ASEE Conferences, p. 27288, Jun. 2016
14. J. J. Heckman and T. Kautz, Hard evidence on soft skills, *Labour Econ.*, **19**(4), pp. 451–464, 2012.
15. A. M. Boelt, J. E. Holgaard and A. Kolmos, A Thematic Analysis of Engineering Students' Experiences of Teamwork in Problem-Based Learning, *Int. J. Eng. Educ.,* **39**(3), pp. 627–642, 2023.
16. "Criteria for Accrediting Engineering Programs, 2021–2022 | ABET." Accessed: Apr. 20, 2023. [Online]. Available: https://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2021-2022/
17. D. Woods, D. Briedis and A. Perna, Professional Skills Needed by Our Graduates, *Chem. Eng. Educ.*, pp. 81–90, 2013.
18. M. Hirudayaraj, R. Baker, F. Baker and M. Eastman, Soft Skills for Entry-Level Engineers: What Employers Want, *Educ. Sci.*, **11**(10), p. 641, 2021.
19. H. Matusovich, R. Streveler and R. Miller, We are teaching engineering students what they need to know, aren't we?, in *2009 39th IEEE Frontiers in Education Conference*, San Antonio, TX, USA: IEEE, pp. 1–6, Oct. 2009.
20. S. Kabicher, R. Motschnig-Pitrik and K. Figl, What competences do employers, staff and students expect from a Computer Science graduate?, in *2009 39th IEEE Frontiers in Education Conference*, San Antonio, TX, USA: IEEE, pp. 1–6, Oct. 2009
21. C. Picard, C. Hardebolle, R. Tormey and J. Schiffmann, Which professional skills do students learn in engineering team-based projects?, *Eur. J. Eng. Educ.*, **47**(2), pp. 314–332, 2022.
22. IBM SPSS Statistics for Windows, IBM Corporation, Armonk, NY, 2021.

Morgan Green, PhD is an Assistant Teaching Professor in the mechanical engineering department at Mississippi State University (MSU). She mainly teaches courses in the thermo-fluids field and conducts research in the engineering education field. As an undergraduate student in 2016, she founded an engineering outreach program for 4th–6th grade girls to learn about engineering through fun, hands-on projects under the guidance of engineering students. She continues to direct the program, Project ENspire, as a faculty member. Dr. Green is also a founding member and current advisor of the Mechanical Engineering Ladies Organization (MELO) at MSU.

Alta Knizley, PhD is an Associate Research Professor at Institute of Clean Energy Technology at Mississippi State University (MSU). Her research areas include thermodynamic and heat transfer modelling, energy sustainability, and engineering education. She has a special interest in enhancing student experience in terms of engineering education and retention, especially for minority and female students. Dr. Knizley is the founder of and an active mentor for the Mechanical Engineering Ladies Organization (MELO) at MSU, and she is also active in ASEE.

Lesley Strawderman, PhD, is a Professor and International Paper Endowed Chair in the Department of Industrial and Systems Engineering at Mississippi State University. Her research expertise is in human factors engineering and engineering education. She has specific interests in technology acceptance modeling, transportation safety, and engineering student efficacy. Dr. Strawderman is a registered Professional Engineer and is an active volunteer in the Society of Women Engineers, Institute of Industrial and Systems Engineers, and ABET.