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Soft Skills Of Engineering Students

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ABSTRACT

Soft skills are a combination of personal qualities and interpersonal abilities that enable individuals to work effectively with others, communicate clearly, and collectively solve problems. Soft skills are required for effective problem-solving and decision-making. Soft skills, such as communication, teamwork, and empathy, are essential for developing a collaborative culture that encourages high order thinking and building relationships. By developing these soft skills, engineering students can improve their chances of success both in their academic pursuits and in their future careers.

The goal of the study was to evaluate soft skills among engineering students, to provide insight to educators that can help in designing better activities which integrate both skillsets holistically and efficiently. 92 Students were asked to fill out anonymous Likert-like questionnaire about their self-reported soft skills. The findings

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indicate no significant differences between students based on extrinsic factors (gender, campus, department and class), which may lead to both theoretical and educational implications. These findings can be utilized to formulate recommendations for combine soft skills into the engineering curriculum.

1 INTRODUCTION

A successful engineering team must possess a range of abilities that encompasses soft skills. Soft skills include the capacity to engage with others successfully and amicably (Oxford Languages; Itani & Srour 2016). Listening, talking (inside oneself and with others), thinking (critically), and summarizing knowledge are necessary for all types of technical efforts. Due to their importance in engineering practice, numerous researchers have focused on developing this ability individually among engineering students (Sousa & Mouraz 2014). Individuals who possess both soft skills are more likely to achieve success in their personal and professional lives. By developing these abilities, individuals can become more effective problem-solvers, decision-makers, and collaborators, and contribute to the development of more resilient and sustainable systems.

In engineering education, significant attention has been paid to the importance of soft skills among undergraduate and graduate students. In view of the importance of soft skills (Shekh-Abed & Barakat 2022), the research detailed in this paper explored whether engineering students differ in soft skills based on gender, campus, department, and class. The theoretical contribution of this work is a quantitative description of the evaluation of soft skills among engineering students. The practical contribution would be to facilitate the development of instructional activities that promote soft skills for engineering students.

The paper opens with a review on soft skills. This is followed by the study purpose and questions are formulated, and the research methodology is outlined. Then, the findings are presented. Finally, discussion and conclusions are presented.

2 THEORETICAL BACKGROUND

Soft skills cover not only relational skills, but also traits like social responsibility, creativity, ethics, and emotional intelligence (Itani & Srour 2016). Consequently, soft skills include the enhanced ability to communicate and interact with others effectively, the ability to think critically, and the ability to incorporate professionalism in engineering practice (Barakat 2015). Organizations strongly emphasize interpersonal skills (e.g., creating rapport) and communication skills (e.g., customizing your message to the appropriate audience). Several institutions, such as the NAE (National Academy of Engineering) and the ABET (Accreditation Council for Engineering and Technology), have increasingly underlined the significance of soft skills in engineering. This has resulted in multiple contribution enriching the literature of soft skills integration in the curriculum (Barakat and Plouff 2014).

According to a study conducted by the Monarch Institute, 85 percent of the abilities required for employability are soft skills, whereas 15 percent are technical skills. This emphasizes the need for teaching soft skills in the classroom. Studies have demonstrated that engineers must be capable of adapting to new information and independently, critically, and proactively express their thoughts. As team members, engineers must develop intrapersonal and self-management abilities that enable them to regulate impulsive inclinations, follow through on promises, accept responsibility, and handle stress. In addition, research has shown that engineering

students must be able to work in teams, manage interdisciplinary groups, and comprehend society in order to discover new solutions to real-world problems. Students must evaluate the environmental, ethical, and political consequences of their acts (de Campos et al. 2020; Klafke 2005).
Caten and his colleagues argue that soft skills are more important than technical abilities for present and future engineers (ten Caten et al. 2019). There are numerous instances of non-technical abilities that make professionals more capable of taking charge of their careers and responding to market needs. These abilities include leadership, innovation, communication, management, ethics, agility, resiliency, and adaptability. The necessary skills for post-university management and leadership positions are those that develop based on humanities and social sciences, such as: demonstrating passion and interest, accepting current roles and responsibilities while seeking continuous improvement; gaining experience in other projects and working groups, understanding and resolving organizational challenges; and self-assessment to learn from mistakes, cultivating values that promote trust (Compton 2008).
Studies (Awuor et al. 2022; Shekh-Abed et al. 2021; Gero et al. 2022) note that through teamwork and project-based learning, students improve their knowledge in the technical, behavioral, and contextual competence areas of project management. Awuor et al. (2022) reveal that students' competences in creativity, leadership, and negotiation have been significantly enhanced thanks to teamwork. Given the focus of the research, the report includes a lengthy self-evaluation questionnaire about employability abilities. In order to teach students to be proactive problem solvers and critical thinkers, the authors recommend that institutions and teachers reevaluate how they already include transferable skills into the curriculum (Ojiako et al. 2011).
Aranzabal et al. (2022) present a way to construct a well-rounded project team as a means to enhance students' performance in project-based learning. In order to get students thinking about the value of teamwork, the authors use Belbin's role theory and find that groups assigned to one of nine roles outperform those assigned by the students themselves. According to Belbin's role theory from 2010, a team member's role is "a tendency to behave, contribute, and interrelate with others in a particular way," with these characteristics being shaped by factors such as one's own personality, cognitive abilities, current values and motivation, field constraints or external working environment, one's own experience and culture, and role learning. Researchers found that when students were exposed to role theory, they improved their abilities to operate in a roles- and skills-based setting, as well as their cooperative learning, interpersonal interactions, and social skills (Aranzabal et al. 2022).

3 RESEARCH PURPOSE AND QUESTIONS

The purpose of the study was to investigate the effect of different extrinsic factors representing demographics (gender), socio-economic status (campus location), technical discipline (engineering program), and educational career stage (class), on the perception and application of soft skills among engineering students. Ultimately, the goal was to provide educators with information that will assist them in planning and instructional design of more effective activities combining soft skills holistically and systematically. The following questions were derived from the research goal:

- Do soft skills perception and application differ among engineering students based on the following factors, and to what extent:

1. Gender (representing demographics)?

2. Campus geographical location (representing socio-economic status)?
3. Engineering program (representing technical discipline)?
4. Class (representing educational career stage)?

4 METHODOLOGY

4.1 Participants

A questionnaire was sent out to all engineering students at The University of Texas at Tyler (UT-Tyler) inquiring about students' perception and application of soft skills. The total number of students who responded to the questionnaire was 92 engineering students. This includes 58 (63%) students from Tyler Main Campus (TYL) and 34 (37%) students from Houston Enginieering Center Campus (HEC). Demographics of the participating students are presented in Table 1. The ratio between male and female students was 2.2 (69% male and 31% female) in both campuses, which is higher than U.S. national average of gender ratio in engineering programs and closer to the international averages of the same ratio. Geographically, TYL Campus is located in a relatively small rural city, while HEC Campus is located in the middle of Houston, which is an enormous major city (inner-City) with a high concentration of less affluent and minority students. Educational career stage included students ranging from Freshman to Seniors, as well as students in the Masters program. Technical disciplines included four engineering disciplines: Civil, Electrical, Mechanical, and Construction Management. It is to be noted that the majority of graduate students who answered the survey are international with a diverse background of engineering education and the accreditation system their universities could have been following.

Table 1. Demographics of participating students responding to questionnaire

Demographic	**Students**
White	39
Hispanic	19
African American	8
American Indian or Native Hawaiian	4
Other	22
Male	60
Female	27
Prefer not to say/Non-binary	5
Total	92

4.2 Procedure

Quantitative method was utilized in this study. An anonymous questionnaire was offered for all engineering students at UT-Tyler in the form of a Qualtrics® questionnaire. Students were invited to voluntarily fill the questionnaire within a week period at the beginning of the spring semester of 2022. Ninety-two engineering students (N = 92) completed this self-reporting questionnaire. The Kolmogorov–Smirnov test of normality (goodness of fit) showed that a normal distribution can be assumed for all variables ($p > 0.05$). Therefore, independent samples t-test and one-way ANOVA test were conducted.

4.3 Instruments

The self-report questionnaire which was composed specifically for this research comprised of 25 statements based on the characteristics of soft skills (Kantrowitz 2005) of engineers. The answers to the questionnaire were based on a five-level Likert scale, ranging between “highly agree” and “highly disagree”, refering to soft skills. The questionnaire was validated by two experts in engineering education. The internal consistency, or coefficient of reliability of the soft skills statements (Cronbach’s α =0.879) were found to be acceptable. Thus, for example, the statement “as a student in an engineering project team, I have confidence in my work and abilities in performing tasks in experiments / project” indicates relatively high soft skills Samples from the soft skills questionnaire are provided in Table 2.

Table 2. Self-reporting questionnaire: soft skills (sample statements)

Statement	Soft Skills
As a student in an engineering project team, I have confidence in my work and abilities in performing tasks in experiments / project	High
As a student in an engineering project team, I collaborate with others to accomplish the task	High
As a student in an engineering project team, I tend not to ask questions or get help from others	Low
As a student in an engineering project team, after making a decision, I often rethink my decision and change my mind	Low

5 RESULTS

Students’ answers were grouped from the questionnaire allowing calculation of the mean score *M* (ranging between 0 and 5) and the standard deviation *SD* for each group of students. The first grouping attempt was by splitting male and female into two separate groups and comparing their results in soft skills. As shown by Table 3, the descriptive statistics (*M*, *SD*) were calculated by gender. According to a t-test (equal variances), there is no significant difference between male and female students in soft skills $t(85) = 0.207$, $p > 0.05$. Both groups (males and females) have the same ability of soft skills.

Table 3. Descriptive statistics for students’ answers grouped by gender

Gender	*N*	Soft Skills	
		M	*SD*
Male	62	4.04	0.48
Female	27	4.09	0.54

The second grouping attempt was by splitting answers based on socio-economic status. This was achieved by grouping responses based on the campus they came from which is either TYL or HEC. As was mentioned, TYL is located in a relatively small rural city with an almost homogeneous population socially and economically. HEC is located in the inner-city part of the enormous city of Houston where the majority of the population is diverse in ethnicity with income around the national poverty level. Comparing results from these groups regarding soft skills as shown by Table 4, the descriptive statistics (*M*, *SD*) were calculated by campus. According to a t-test (equal variances), there is no significant difference between TYL and HEC in soft skills t(90) = -0.086, p >0.05. Therefore, students in both campuses have the same perception and application experiences of soft skills.

Table 4. Descriptive statistics for students' answers grouped by campus

Campus	*N*	**Soft Skills**	
		M	*SD*
TYL CAMPUS	58	4.00	0.49
HEC CAMPUS	34	4.15	0.47

The third grouping attempt was by splitting answers based on technical disciplines represented by the home departments of students. This produced four separate groups. Descriptive statistics of the four groups are shown in Table 5, the descriptive statistics (*M*, *SD*) were calculated by departments. According to a one-way ANOVA test (equal variances), there is no significant difference in soft skills F(3, 88) = 0. 861, $p > 0.05$, between the engineering departments. Students in different engineering departments have similar abilities, perceptions, and experiences regarding soft skills.

Table 5. Descriptive statistics for stud ents' answers grouped by department

Department	*N*	**Soft Skills**	
		M	*SD*
Mechanical Engineering	62	4.11	0.47
Electrical Engineering	13	3.91	0.54
Civil Engineering	11	3.92	0.60
Construction Management	6	4.08	0.38

The fourth grouping attempt was by splitting classes (studying year) into five separate groups of students (Freshman, Sophomore, Junior, Senior, and Graduates) and comparing their results in soft skills. As shown by Table 6, the descriptive statistics (*M*, *SD*) were calculated by class in terms. According to a one-way ANOVA test (equal variances), there is no significant difference in soft skills F(4, 87) = 1.591, $p > 0.05$, between the engineering classes in terms. Students in different engineering disciplines have similar abilities and perceptions of soft skills.

Table 6. Descriptive statistics for students' answers grouped by class

Class	*N*	**Soft Skills**	
		M	*SD*
Freshman	9	3.80	0.69
Sophomore	4	3.87	0.19
Junior	18	4.22	0.46
Senior	40	4.11	0.46
Graduates	21	3.95	0.47

6 SUMMARY

Soft skills such as active listening, empathy, and collaboration are necessary for establishing trust and fostering relationships with others. Individuals are more likely to be able to identify and address systemic problems and work towards sustainable solutions if they are able to work effectively with others and establish strong relationships.

Results collected and presented in the results' section show that soft skills perception by students has no significant differences based on extrinsic factors such as gender and socio-economic level. In fact, results show that there are no significant differences in soft skills perception by students based on gender, campus (Geographical location), department (Career), and class (stage in the career or year of study). This suggests that current methods and techniques to build and improve soft skills are effective and that all students may benefit from expanded dedicated activities to improve soft skills.
Since there are no significant differences among the different groups, it may be worthwhile to develop activities that are universally applicable to all students which expand from current proven methods for soft skills development. This could involve workshops, seminars, or other training sessions focused on developing soft skills. In addition, it may be helpful to integrate these skills into the curriculum in a more deliberate and intentional manner. This could involve incorporating activities and assignments that specifically target the development of soft skills. Combining reflection assignments and project-based learning into engineering courses (Shekh-Abed & Stav 2023) could enhance both hard and soft skills.
Overall, the findings suggest that there is a need for dedicated activities to improve soft skills for all students, regardless of gender, campus, department, or class. By addressing these skill sets in a more intentional and deliberate way, students may be better equipped to succeed in their academic and professional pursuits.

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