NSF Grantee Poster Session
Undergraduate's Social Capital and Engineering Professional Skills: Comparison Between Different Types of Institutions

Introduction

The purpose of our poster presentation is two-fold: 1) to provide an overview of our NSF project, *Pandemic Impact: Undergraduates' Social Capital and Engineering Professional Skills,* and 2) to report our progress and preliminary quantitative findings. We hope to discuss our project and preliminary results with fellow engineering educators and receive feedback.

The COVID-19 pandemic has impacted engineering education in multiple ways that will continue to be felt for years to come. One of the less understood ways the pandemic has continued to leave a residue on engineering education is how social distancing and online courses altered students' professional development. Of particular concern are students who were either new to the institution or started their college education during the pandemic. These students have potentially limited opportunities to establish social relationships at their educational institutions compared to students who already developed such relationships when the pandemic-induced online learning took place. The differences in students' social relationships can have other, more profound impacts on their undergraduate engineering experiences. Research has shown that students' social relationships provide them with connections to resources and supports essential for navigating an engineering program and help them obtain more opportunities to practice non-technical professional skills [1], [2]. Although social distancing measures diminished and students returned primarily to in-person, the pandemic has altered the development of engineering students in ways not understood. In particular, understanding the nature of students' social interactions on campus and the types of opportunities for professional development is essential so that instructors and campus staff can respond to the developmental needs of students. As a result, the overarching research question for our project is: *How do engineering undergraduates leverage relationships (operationalized as social capital) to gain opportunities to develop professional skills?*

Project Overview & Progress

Our project adopts an explanatory sequential mixed methods research design. To answer our overarching research question, we developed six sub-scale research questions, designed to be addressed first by quantitative data analysis and then by qualitative data analysis. The sub-scale research questions and data sources used to answer these questions are listed in Table 1. As students may have different experiences depending on the type of their educational institutions, we adopted a probabilistic stratified cluster sampling approach [3] to ensure that we have equal representation of students from four strata: research, undergraduate, Hispanic-serving and minority-serving (HSI/MSIs), and historically Black Colleges and Universities (HBCUs). We identified these four strata based on the Carnegie Classification [4].

In the Spring of 2022, we collaborated with 13 institutions (research, MSI/HSI, HBCU, and undergraduate institutions) to recruit undergraduate engineering students to take the Professional Skill Opportunities (PSO) and the Undergraduate Student Support (USS) surveys. The PSO

survey asked students about their opportunities to practice professional skills, including problem-solving, business and management principles, communication, professional and ethical responsibilities, and shared leadership, a combination of teamwork and leadership skills. The USS survey inquired about the verbal encouragement and emotional support students received (i.e., expressive support) and the tangible resources that helped them succeed in engineering (i.e., instrumental support). The researchers incentivized participants with a $20 Amazon gift card. A total of 1,234 participants across the 13 institutions completed the survey.

Table 1

Project Research Plan

Phase	Research Question	Data Source(s)
Quantitative	To what extent does engineering students' social capital predict their opportunities for professional skill development?	USS + PSO surveys
	To what extent do students in different first-year cohorts have significantly different levels of social capital?	USS survey
	To what extent do students in different cohorts have different reported levels of opportunities for professional skill development?	PSO survey
Qualitative	How do students from each cohort report using social capital to develop professional skills?	Semi-structured critical incident interviews based on participants' USS & PSO responses.
	How do students describe opportunities for developing professional skills in course-based and co-curricular settings?	
	How are students developing high levels of social capital during the pandemic?	

Quantitative Preliminary Results – Differences Between Strata

Tables 2 and 3 below present the descriptive statistics of USS and PSO scores across different strata. We conducted a multivariate analysis of variance (MANOVA) using the multivariate Kruskal-Wallis test as the non-parametric equivalent and the recommended post-hoc test [5], Scheffé's test [6], to investigate whether strata can lead to significant differences in students' social supports and their perceived opportunities to practice professional skills. The multivariate Kruskal-Wallis test revealed that there are significant differences between strata in students'

reported USS (χ^2 = 39.72, p < .001) and PSO scores (χ^2 = 42.95, p < .001). Post-hoc test results revealed that students from undergraduate institutions reported higher levels of social support than students from research institutions and MSI/HSIs. For PSO scores, no significant differences between strata on various professional skills opportunities were detected via Scheffé's test using α = 0.05. However, when using the significant level of α = 0.1, students from research institutions reported significantly more opportunities to practice ethics and professional responsibilities skill (M = 5.0, SD = 1.2) than students from MSI/HSI (M = 4.7, SD = 1.2, F(4, 613) = 23.41, p < .10). Table 4 shows the significant mean differences between strata for USS scores.

Table 2

Descriptive Statistics for Students' USS Scores.

	Undergraduate	Research	MSI/HSI	HBCU
n	166	235	149	64
Expressive Social Capital	2.0 (1.1)	1.6(1.0)	1.5(1.1)	1.8(1.2)
Instrumental Social Capital	1.4 (0.9)	1.1 (0.8)	1.0 (0.9)	1.4 (1.0)
Accessed Resources	1.8 (0.9)	1.6 (0.8)	1.4 (0.8)	1.7 (0.8)

Note. Standard deviations are shown in parentheses. Expressive and Instrumental Social Capital scores are on a scale of 0 to 5, with 0 = absence of social support and 5 = high levels of social support received. The Accessed Resources score is on a scale of 0 to 7, with 0 = absence of a social resource and 7 = high levels of presence for a social resource.

Table 3

Descriptive Statistics for Students' PSO Scores.

	Undergraduate	Research	MSI/HSI	HBCU
n	168	225	160	64
Problem-Solving	5.3 (1.1)	5.5 (1.1)	5.2 (1.2)	5.3 (1.0)
Communication	5.6 (1.0)	5.7 (1.0)	5.5 (1.2)	5.6 (0.9)
Ethics and Professional Responsibilities	5.0 (1.0)	5.0 (1.2)	4.7 (1.2)	4.9 (1.1)
Business and Management Principles	4.0 (1.5)	4.2 (1.4)	3.8 (1.5)	4.3 (1.3)
Shared Leadership	5.2 (1.0)	5.4 (1.1)	5.3 (1.2)	5.4 (0.9)

Note. Standard deviations are shown in parentheses. All the scores in PSO are on a scale of 1 to 7, with 1 = don't practice a professional skill at all, and 7 = practice a professional skill very frequently.

Table 4

Significant Mean Differences of USS scores.

Dependent Variable	Strata (I)	Strata (II)	Mean difference (I – II)	*p*

Expressive Social Capital	Undergraduate	MSI/HSI	.50	.001
		Research	.42	.003
Instrumental Social Capital	Undergraduate	MSI/HSI	.43	<.001
		Research	.33	.004
Accessed Resources	Undergraduate	MSI/HSI	.46	<.001
		Research	.23	.048

Note. Results were produced using Scheffe's test.

Future Work & Implications

This poster is part of our effort to how the pandemic might have influenced students' social relationships and the way they leverage these relationships to gain opportunities to develop professional skills. The preliminary quantitative results presented in this work provide insights into our next steps. Additional quantitative analysis will focus on two aspects: 1) revealing the relationship between students' social supports and their professional skill development opportunities; and 2) investigating survey score differences among students from different cohorts. More specifically, we plan to use a generalized linear mixed model to explore relationships between social capital and professional skill development opportunities and use multivariate analysis of covariance to analyze whether group differences among cohorts exist within our sample. On the qualitative aspect of the project, the preliminary results provide a direction for identifying research participants and structuring interview questions. We will recruit students with varying levels of social capital, as indicated by our survey results. During our interview recruitment process, we will focus on reaching out to students with varying levels of social supports, as well as from a diverse background in terms of their educational institutions, race/ethnicity, gender, etc. This, in turn, can allow us to collect detailed descriptions of the kind of social resources students receive and how they utilize them to develop professional skills.

Studying how undergraduate engineering students utilize their social resources to facilitate their professional skill development and how the pandemic impacted this process will yield valuable insights into engineering education, as the pandemic may have resulted in a lasting impact on the nature of social interactions. Ultimately, we hope to inform students, educational institutions, and educators of ways to support students, establish and maintain social support and help them become professionals who are fluent in vital non-technical skills.

Acknowledgement

This material is based upon work supported by the National Science Foundation under Grant No. 2129308 & 2129282. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

References

[1] J. P. Martin, S. K. Stefl, L. W. Cain, and A. L. Pfirman, "Understanding first-generation undergraduate engineering students' entry and persistence through social capital theory," *Int. J. STEM Educ.*, vol. 7, no. 1, pp. 37–37, 2020, doi: 10.1186/s40594-020-00237-0.

[2] S. D. Garrett, J. P. Martin, and S. G. Adams, "Developing nontechnical professional skills in African American engineering majors through co-curricular activities," *IEEE Trans. Educ.*, 2021, doi: 10.1109/TE.2021.3120210.

[3] E. Blair and J. Blair, *Applied survey sampling*. Los Angeles, CA: SAGE Publications, Inc., 2015.

[4] Indiana University Center for Postsecondary Research, "Carnegie Classifications | Listings." https://carnegieclassifications.acenet.edu/lookup/standard.php (accessed Feb. 10, 2023).

[5] B. M. Katz and M. McSweeney, "A Multivariate Kruskal-Wallis Test With Post Hoc Procedures," *Multivar. Behav. Res.*, vol. 15, no. 3, pp. 281–297, Jul. 1980, doi: 10.1207/s15327906mbr1503_4.

[6] Scheffé, Henry, *The Analysis of Variance*, vol. 72. John Wiley & Sons, 1999. Accessed: Feb. 10, 2023. [Online]. Available: https://www.wiley.com/en-gb/The+Analysis+of+Variance-p-9780471345053