Exploring the Relationships between Engineering Internships and Innovation and Engineering Task Self-Efficacy

Abstract— **This research to practice full paper presents the work of an academic-industry research partnership to explore the internship experiences of summer interns at a large global engineering company. Engineering internships give students the opportunity to apply the engineering skills they have been learning to real products and can have a high impact on innovation and engineering task self-efficacy. The relationship between internships and innovation and engineering task self-efficacy matters because self-efficacy is an important predictor of major and career choice. Innovation interests is another measure that measures the individual's interest in innovative behaviors, unlike ISE which measures their confidence in practicing these behaviors. This paper focuses on understanding the relationship between internship work assignment and supervisor interaction and innovation interests. Furthermore, the relationship between the internship experience and the intern's likelihood of accepting a job offer from the same company is explored. A survey administered to engineering interns (N = 115) at the end of their summer 2017 internship at a large global engineering company forms the main dataset for this work.**

Keywords—Engineering Education Research, Industrial Partnerships and Collaborations, Engineering Education Research, Innovation and Creativity

I. INTRODUCTION

Internships are an important part of the engineering education experience. A majority of engineering students work as an intern in an engineering environment [1]. Previous research has found that working in a professional engineering environment (i.e., a summer engineering internship) was an important predictor of innovation self-efficacy (ISE) and engineering task self-efficacy (ETSE) [1], and that engineering interns have higher ISE and ETSE than engineering students generally [2]. ISE and ETSE represent one's confidence in innovation and one's confidence in technical engineering tasks, respectively. Engineering interns have been found to have, on average, higher self-efficacy levels than engineering students in general [1]. Summer internships, along with undergraduate research, have also been found to be critical mastery experiences that correlate with higher ETSE values for Underrepresented Racial/Ethnic Minority (URM) women in particular [3]. While ISE measures an individual's confidence in innovative behaviors, the innovation interests (INI) scale measures an individual's perspectives in various stages of the innovation process.

Internships offer engineering students the opportunity to apply their engineering knowledge to actual products and in real world situations. [Anonymous, 2018] found that engineering interns completing their undergraduate degrees expected to do some learning on the job, although they generally felt adequately academically prepared for the internship [4]. Being able to see how the principles engineering students have learned in class are applied in the design of new products in industry could spark interest in innovation. Specifically, the intern's experience with their work assignment is potentially correlated with their interests in practicing innovative behaviors.

Some companies aim to hire interns on full time after they graduate, and many students seek internships to enhance their resumé and possibly result in a job offer. It is important to understand what factors influence an intern's decision to accept or decline a job offer at the end of a summer internship. While the details of the offer itself are important, the entire internship experience informs the decision-making process. A study of 111 undergraduates who engaged in internships, mostly in business, found that interns who had the chance to learn new information and lessons during their internship were more likely to be satisfied with their internship experience [5]. Additionally, having a supervisor who gave feedback and acted as a mentor strongly influenced the intern's satisfaction with their internship experience [5]. Similarly, a study of 127 undergraduates who participated in retail industry internships found that job satisfaction had a significant impact on an intern's decision to accept a job offer [6]. The type of assignments interns work on and the type of interactions interns have with their supervisor are important to undergraduate interns generally. This paper investigates the work assignment and supervisor interactions of engineering interns, and how the relationship between these components of the internship are related to innovation self-efficacy and plans to accept or decline a possible job offer.

II. DATASETS

A. Engineering Majors Survey

The Engineering Majors Survey (EMS) is a longitudinal study first administered in 2015 to over 30,000 undergraduate engineering students across a nationally representative sample of 27 U.S. engineering schools. This NSF-funded study focused on engineering students' interests and career goals related to innovation and entrepreneurship. The data analyzed in this paper was collected from 5528 engineering students across the U.S.

B. Large Engineering Company Intern Survey

In order to gather information about the internship experience, surveys were distributed to product development interns at the end of their 2017 summer internships at a large Fortune 500 company. This globally distributed company employs about 25,000 engineers representing nearly all engineering majors.These surveys included standard post-internship evaluation as well as additional items about topics related to innovation and engineering self-efficacy. Of the 115 product development interns that responded to the survey, 72% were male and 65% were white. The full demographic breakdown is shown in Table 1.

TABLE I. INTERN DEMOGRAPHICS

Large Engineering Company Interns N = 115		
Gender	***N***	***%***
Females	22	19.1%
Males	83	72.2%
Missing	10	8.7%
Underrepresented Minority (URM)	***N***	***%***
URM	9	7.8%
Non-URM	94	81.7%
Missing	12	10.4%
Intern Status	***N***	***%***
First Time Intern	102	88.7%
Returning Intern	13	11.3%
Missing	0	0%

Most of the interns, 88.7%, were interning at this large engineering company for the first time. There were also 13 returning interns (interning at this same company for multiple summers). The interns were primarily in bachelor degree programs, 76.5%, although there were also 18 masters students and 7 PhD students. The majority of interns were majoring in engineering, with 61 mechanical engineering majors, 15 electrical/electronics/communications engineering majors, and 24 students who were majoring in various other branches of engineering (automotive engineering, chemical engineering, etc.). Of the non-engineering majors, there were 7 computer science majors, 1 finance major, 1 human computer interaction major, 2 transportation design majors, and 1 MBA student. 3 respondents did not answer the question about their major.

C. Description of Variables in the EMS and Engineering Company Datasets

Three measures were examined in both datasets are described in greater detail in [7].

Innovation Self-Efficacy (ISE): Measures one's confidence in their ability to innovate, i.e. to engage in specific behaviors that characterize innovative people and consists of the average of the five items, each measured on five-point Likert scales from "Not confident" (0), to "Extremely confident" (4)

Engineering Task Self-Efficacy (ETSE): Measures one's confidence in their ability to perform integral technical engineering "tasks" such as "analyzing the operation or functional performance of a complete system" and consists of the average of five items, each measured on the same Likert scale (of confidence) mentioned above.

Innovation Interests (INI): Measures the average of seven aspects of the respondents' orientation to one (early) stage of innovation: discovery and idea generation. Each aspect is measured on a five-point Likert scale from "Very low interest" (0) to "Very high interest" (4).

The mean ISE for the interns in this study was 3.16 out of 4, with a standard deviation of 0.61. This is slightly higher than the ISE of respondents to the Engineering Majors Survey (EMS), as found in [2].

TABLE II. COMPARISON OF INNOVATION SELF-EFFICACY AND ENGINEERING TASK SELF-EFFICACY MEAN SCORES

	Large Engineering Company Interns		**EMS Respondents**	
	M (SD)	***N***	***M (SD)***	***N***
ISE	3.16 (0.61)	5528	2.62 (0.74)	110
ETSE	3.03 (0.69)	5528	2.42 (0.85)	80

In addition to questions about demographics, the survey included 9 items about the intern's interactions with their supervisor, and 12 items about the intern's work assignment. These Respondents rated statements about their work assignment and direct supervisor on a five-point scale from "Strongly Agree" to "Strongly Disagree." These questions sought to understand both the practicalities of the internship (e.g. S.2 My supervisor conducted a mid-summer review with me to discuss my performance.) and the intern's personal experience with the internship (e.g. W.9 I was satisfied with the challenging work I was provided.).

D. Creating Scales for Work Assignment and Supervisor Interaction Questions

In the Large Engineering Company dataset, two scales were created to measure interns' perceptions about their work assignment and interactions with their supervisors. The constituent items for both of these scales included statements where interns were prompted to indicate their agreement on a five-point Likert scale ranging from "Strongly Disagree" to "Strongly Agree."

The *Work Assignment Scale* ($\alpha = .93$) focused on a set of nine statements largely centered around tasks and opportunities that the intern would be able to pursue and engage in, such as "I had the autonomy to make independent decisions" and "I could see a clear connection of how my work assignment would contribute to business results."

The *Supervisor Interaction Scale* ($\alpha = .93$) was computed by taking the average level of agreement with 11 statements, each representing externally facilitated aspects of their summer internship that were, for the most part, outside of the immediate purview of the intern with a specific focus on the role of the supervisor. For example, interns indicated to what degree their supervisor provided valuable performance

feedback, recognized their work, and made their internship a positive experience.

III. Results and Analysis

A. Innovation Interests

Engineering internships present the opportunity for engineering students to apply the principles they have been learning to real problems and products, and as such could be a valuable opportunity for students to increase their innovations interests. Both the Work Assignment Factors and Supervisor Related Factors scales have a significant positive correlation with the innovation interests scale, as shown in Table 3.

TABLE III. Correlations Among Innovation Interests and Supervisor and Work Assignment Scales

	Innovation Interests (5) Scale
	Pearson Correlation **N=80**
Supervisor-Related Factors Scale	0.319**
Work Assignment Factors Scale	0.350***
*** p<.001 ** p<.01 * p<.05	

Pearson correlation analyses were conducted to further investigate the relationship between individual work assignment and innovation interests. Ten of the twelve work assignment items were significantly and positively correlated with innovation interests, see Table 4. This suggests a link between having high innovation interest and having a satisfactory work assignment. The two items that were not significantly correlated with innovation interests, *W.1 receiving a work plan at the beginning of the internship* and *W.2 being contacted by the supervisor prior to the internship start date*, were not very related to the quality or substance of the work assignment. Thus, it is not surprising that these more clerical items were not significantly correlated with innovation interest.

Item *W.7 being able to implement ideas for improvement* was significantly and positively correlated with innovation interests, with a correlation coefficient of 0.35 (p<.001). A project where interns' ideas could be utilized could definitely be a motivation and incentive to continue generating and sharing suggestions.

Item *W.5 teamwork* was significantly and positively correlated with innovation interests (r=0.34, p<.001). Innovation often involves working with others to generate new ideas. Additionally, a work assignment that involved more teamwork would likely expose the intern to more people, projects, and opportunities.

Additionally, item *W.3 being provided sufficient direction to complete the work assignment* was significantly and positively correlated with innovation interests (r=.34, p<.001). Although innovation involves experimentation and discovery, being interested in innovative behaviors was still positively correlated with having enough instructions. This seems surprising; however, having enough direction to complete assigned tasks likely builds interns' confidence in their work and leads to an increased interest in continuing to improve that work.

Interns who agreed the management presentation was a good way to demonstrate the results of their work assignment (W.11) tended to be more interested in innovative behaviors. This item was positively correlated with innovation interests (r=.32, p<.001). One of the five items used to gauge innovation interest was "Giving an elevator 'pitch' or presentation to a panel of judges about a new product of business idea." It is not surprising that individuals who thought presenting to management was a good way to demonstrate the results of their work assignment would also be more interested in pitching a new product idea.

TABLE IV. Work Assignment Items and Innovation Interests

		Innovation Interests (5) Scale
		Pearson Correlation **N=107**
W.1	I received a copy of my work plan that included my specific objectives and deliverable.	0.174
W.2	My supervisor contacted me prior to my start date	-0.016
W.3	**I was provided sufficient direction to complete my work assignment.**	**0.344****
W.4	I had autonomy to make independent decisions.	0.279**
W.5	**I had sufficient opportunities to develop new skills.**	**0.339****
W.6	I was satisfied with the amount of teamwork I experienced with my work assignments.	0.259**
W.7	**Ideas for improvement were easily implemented in my work environment.**	**0.353****
W.8	My work assignment allowed me to work to my potential.	0.255**
W.9	I was satisfied with the challenging work I was provided.	0.293**
W.10	I could see a clear connection of how my work assignment would contribute to business results.	0.295**
W.11	**The management presentation provided a good way for me to demonstrate the results of my work assignment.**	**0.320****
W.12	Overall, I was satisfied with my work assignment.	0.241*
***** p<.001 ** p<.01 * p<.05**		

Seven of the nine of the items relating to interactions with supervisor were also positively correlated with innovation interests on at least the 0.05 level, as shown in Table 5. In particular, interns who had a high level of agreement with statements indicating having a supervisor who established performance objectives during the first week of the internship and who provided the intern with valuable performance feedback also reported higher innovation interests. Feedback seems to be a critical element in relation to innovation interests. However, having a mid-summer review was not significantly correlated with innovation interests. While it appears that feedback is essential, that feedback might not need to take the form of a formal review in order to contribute to the intern's innovation interests.

TABLE V. Supervisor Items and Innovation Interests

	Innovation Interests

		(5) Scale
		Pearson Correlation **N=107**
S.1	**My supervisor established performance objectives in the first week of my internship.**	**0.308****
S.2	My supervisor conducted a mid-summer review with me to discuss my performance.	0.171
S.3	**My supervisor provided me with valuable performance feedback.**	**0.309****
S.4	My supervisor provided recognition of my work.	0.277**
S.5	My supervisor did a good job making my internship experience positive.	0.207*
S.6	My supervisor was accessible.	0.126
S.7	I had a career-related discussion with my supervisor.	0.230*
S.8	My supervisor played a mentor role and provided guidance beyond my set objectives.	0.262**
S.9	Overall, I was satisfied with the quality of supervision.	0.297**
*** p<.001 ** p<.01 * p<.05		

B. Considering a Job Offer

Some companies are interested in the "conversion rate" from their intern program—how many interns are converted in full time employees. New employees who are socially isolated and lack meaningful work are at increased risk for dissatisfaction and attrition [8]. This suggests that having meaningful social interactions and work assignments would also be an important factor when interns are deciding whether or not to accept a job offer at the end of the summer.

To explore this further, we created two groups based on the responses to the categorical question: "If you receive an offer of employment from [the company], how likely is it that you would accept?" While this question captures only the intern's intentions to accept an offer and not their final decision, [9] found that an intern's intention to accept an offer was a strong predictor of the actual conversion of the intern after graduation.

It is surprising that 96% of the male interns were in the Likely to Accept Offer group, while the female interns were evenly split between the two groups (51% Likely to Accept Offer, 49% Unsure/Unlikely to Accept Offer).

TABLE VI. GENDER AND INTERN STATUS FOR UNSURE/UNLIKELY TO ACCEPT OFFER AND LIKELY TO ACCEPT OFFER GROUPS

Gender	**Unsure/Unlikely to Accept Offer N (%)**	**Likely to Accept Offer N (%)**
Females	17 (85%)	18 (20.7%)
Males	3 (15%)	69 (79.3%)
Intern Status		
First Time Intern	17 (85%)	84 (89.4%)
Returning Intern	3 (15%)	10 (10.6%)
TOTAL	20 (17.5%)	94 (82.5%)

In order to examine the differences between the Unsure/Unlikely to Accept Offer group and the Likely to Accept Offer group, an independent samples t-test was conducted, as shown in Table 7. Given the differences in group sizes, the Levene's test for homogeneity of variances was conducted.

TABLE VII. DIFFERENCES IN MEAN (SD) SCORES FOR WORK ASSIGNMENT AND SUPERVISOR INTERACTION SCALES AND INNOVATION INTERESTS, ISE, AND ETSE VARIABLES FOR UNSURE/UNLIKELY TO ACCEPT OFFER AND LIKELY TO ACCEPT OFFER GROUPS

Variable/Scale	**Unsure/ Unlikely to Accept Offer M (SD)**	**Likely to Accept Offer M (SD)**	***t***	***df***	***Sig.***
Work Assignment Factors Scale	2.76 (1.05)	3.32 (.66)	-2.31	22.31	*
Supervisor Interactions Scale	2.84 (1.00)	3.25 (.66)	-1.74	22.68	NS
Innovation Interests (5) Scale	2.64 (.62)	2.93 (.63)	-1.80	104	NS
Innovation Self Efficacy	3.10 (.53)	3.17 (.62)	-.43	107	NS
Engineering Task Self Efficacy	2.91 (.77)	3.06 (.67)	-.75	77	NS
*p <.05					

Supervisor interactions were not significantly different for the Unsure/Unlikely and Likely to Accept Offer groups. This is in line with the findings of [9], which found that the interactions and relationship between the intern and supervisor, were not significantly related to the intern's intention to convert to a full-time employee.

Work assignment was significantly different for the Unsure/Unlikely and Likely to Accept Offer groups. Interns who indicated they were Likely or Very Likely to accept a job offer from the company were more satisfied with their work assignment, scoring a mean of 3.32 on the Work Assignment Factors Scale as opposed to a mean of 2.76. Several individual work assignment items were also significantly higher for the Likely to Accept Offer Group; selected items are shown in Table 8.

Learning on the job is a common aspect of satisfactory work assignments. Both items W.5 and W.9, which relate to opportunities to develop new skills and having challenging work, were significantly different for interns in the Unsure/Unlikely and the Likely to Accept Offer groups. It was also important for interns to see a clear connection between their work assignment and larger business results (item W.10), for interns to have the opportunity to work with others (item W.6), and for interns to have a clearly defined work assignment (item W.1). The overall quality of the work assignment was significantly higher for interns in the Likely to Accept Offer group.

TABLE VIII. SIGNIFICANT DIFFERENCES IN MEAN (SD) SCORES FOR SELECTED WORK ASSIGNMENT AND SUPERVISOR INTERACTION ITEMS FOR UNSURE/UNLIKELY TO ACCEPT OFFER AND LIKELY TO ACCEPT OFFER GROUPS

Variable/Scale		**Unsure/ Unlikely to Accept Offer M (SD)**	**Likely to Accept Offer M (SD)**	***t***	***df***	***Sig***
W.1	I received a copy of my work plan that included my specific objectives and deliverable.	2.25 (1.51)	3.04 (.98)	-2.23	22.5	*

W.5	I had sufficient opportunities to develop new skills.	3.10 (1.02)	3.54 (.61)	-2.56	112	*
W.6	I was satisfied with the amount of teamwork I experienced with my work assignments.	2.50 (1.27)	3.20 (.99)	-2.73	112	**
W.9	I was satisfied with the challenging work I was provided.	2.25 (1.55)	3.19 (.93)	-2.61	21.9	*
W.10	I could see a clear connection of how my work assignment would contribute to business results.	2.85 (1.26)	3.52 (.78)	-2.27	22.2	*
W.12	Overall, I was satisfied with my work assignment.	2.40 (1.60)	3.36 (.80)	-2.61	21.0	*
*** p<.001 ** p<.01 * p<.05						

C. *Common Work Assignment Items*

The following items were relevant in both the innovation interests and job offer analyses. These items merit special consideration from employers and engineering students alike.

Item W.5, "I had sufficient opportunities to develop new skills" was significantly different for the Unsure/Unlikely and Likely to Accept Offer groups as well as being significantly correlated with innovation interests. Working in a professional engineering setting can present many opportunities for interns to learn new engineering skills as well as new professional skills. Through interviews to product development summer interns, [4] found that interns learned new software programs and professional communication skills, among other skills, during their internship. The relationship between opportunities to develop new skills and accepting an offer indicates that engineering companies should make incorporating learning opportunities into internships a priority. Additionally, students should seek out internships where they will have opportunities to learn new things.

Overall satisfaction with the work assignment, item W.12, was also significantly related to both likelihood of accepting a job offer and innovation interests, see Table 4. and Table 8. Furthermore, the Work Assignment Factors Scale was significantly higher for the Likely to Accept Offer group than the Unsure/Unlikely to Accept Offer group and significantly and positively correlated to innovation interests. The work assignment is a crucial element of the engineering internship. Engineering companies must carefully plan work assignments for their summer interns if they want the interns to strongly consider accepting a job offer. When selecting an internship, engineering students should consider what their work assignment will be.

IV. Discussion

Engineering internships can be a very important experience for engineering students. During an internship, the intern's work assignment and the intern's interactions with their supervisor play important roles in the intern's overall satisfaction with their internship, the intern's interest in innovation, and the intern's intention to accept a job offer.

Evaluating the quality of an internship is more complex than simply looking at the conversion rate of interns to employees. The quality of an internship has several dimensions, and which of those is most critical depends on who is evaluating the internship. Companies may be most interested in conversion rate. Engineering students may be interested in conversion rate, learning opportunities, and increase in self-efficacy. Engineering educators may be interested in learning opportunities and increase in self-efficacy.

For example, while the supervisor interactions were not significantly related to an interns' intent to accept a job offer (implying supervisor interactions would be unimportant to companies looking solely at intern conversion rate), supervisor reactions were significantly related to innovation interests. If companies want to convert interns to employees, and have innovative employees, they must emphasize the importance of positive, quality interactions between interns and supervisors.

Work assignment is another critical aspect of engineering internships. Engineering interns who were satisfied with their work assignment were more likely to have high innovation interests and more likely to accept a job offer.

V. Limitations and Future Work

The survey this analysis was based on was administered only to product development interns at a single large engineering company in 2017 and cannot represent the wide variety of engineering internship experiences.

The percentage of women who were unlikely to or unsure about accepting a job offer was surprisingly much higher than that of men. Future work will include investigating the experience of women engineering interns specifically and their process in deciding whether or not accept a full time offer after an internship. How are women's experiences with engineering internships and deciding where to accept full time offers different from the experiences of men?

VI. Acknowledgments

References

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