A Mixed Methods Approach to Understanding How Colleges, Universities, and Employers Prepare and Support Undergraduates in Engineering Internships

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***Abstract*— This Research to Practice Work In Progress Paper describes an academic-industry research partnership aimed at understanding how undergraduate juniors and seniors navigate a summer internship at a large global engineering company in the automotive industry. The study explores the question: *What are the relationships between internship experiences and engineering students' self-efficacy, creativity and innovation, and future academic and career choices and plans?* Focusing on survey and interview data collected from product development interns at a single engineering firm, this research explores the highlights and challenges encountered in their internship as well as their perceptions regarding opportunities for creativity and innovation. An additional set of interview questions examined the organizational ecology within the company based on who interns interacted with and sought out for mentorship and support. These results are contextualized in findings from a survey of undergraduate engineering students across a nationally representative sample of 27 U.S. engineering schools. Future research based on survey and interview data will take a mixed methods approach to inform an actionable understanding of the role of engineering internships for three critical stakeholders across whom an engaging & effective pathway is sought: students, colleges & universities, and industry.**

Keywords—internships, self-efficacy, innovation, career plans, academic-industry research partnerships

I. Introduction

According to the 2016 Gallup-Purdue Index Study -- a nationally representative study of U.S. college graduates with Internet access -- over half of the respondents reported having a job or internship as an undergraduate that allowed them to apply what they learned in the classroom [1]. The National Association of Colleges and Employers describes an internship as "…a form of experiential learning that integrates knowledge and theory learned in the classroom with practical application and skills development in a professional setting. Internships give students the opportunity to gain valuable applied experience and make connections in professional fields they are considering for career paths; and give employers the opportunity to guide and evaluate talent." [2]

Exposure to the engineering field via technical internships and co-ops may be particularly attractive to students wishing to gain practical experience in industry as well as strengthen their qualifications for positions after graduation. [3], [4] and the findings resulting from the National Survey of Student Engagement have identified positive outcomes associated with internships and other high impact practices such as higher retention and persistence rates and student success [5]. [6] found that exposure to professional engineering workplaces and projects is a positive predictor of plans for engineering work, and a negative predictor of plans for non-engineering work after graduation. Yet, more focused research on the impact of internships specifically involving engineering work or the internships sought out by engineering majors is not as extensive.

The current study aims to provide a more nuanced exploration of understanding the experiences of engineering majors completing a summer internship at a large Fortune 500 company. This globally distributed company employs about 25,000 engineers representing nearly all engineering majors. The research question guiding this research asks: ***What role do experiences and interactions in the engineering workplace play in students' interests and abilities as they may relate to their post-graduation plans?***

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II. METHODS AND DESCRIPTION OF DATASETS

This study draws upon three independent data sets – two sets of quantitative survey data and a third qualitative structured interview dataset.

A. *Engineering Majors Survey Dataset*

The Engineering Majors Survey (EMS) was a major initiative of the NSF-funded National Center for Engineering Pathways to Innovation (Epicenter) focusing on understanding engineering students' interests and career goals around innovation and entrepreneurship (I&E). It was first administered in Winter/Spring 2015 to over 30,000 undergraduate engineering students across a nationally representative sample of 27 U.S. engineering schools. The survey instrument included 35 questions covering five main topics/sections: (1) Current Plan of Study, (2) School Experiences, (3) Beliefs, Expectations, and Interests, (4) Future Career Goals and (5) Background. The EMS also included specific questions about past and current involvement and interest in research and internships. These learning experiences often become hallmarks of an undergraduate engineering education and inform students' career goals, interests in innovative work and self-efficacy [7], [8].

The EMS 1.0 dataset used for this study included 6,187 junior and seniors. Of this sample, 3,235 respondents reported working in a "professional engineering environment as an intern/co-op" for at least one full academic or summer term while an undergraduate and were included in the study analyses.

B. *Large Engineering Company Intern Survey Dataset*

At the completion of their summer internships in a large engineering company in August-September 2017, the student interns completed an exit survey evaluating their experiences. The interns in the product development division completed an additional set of survey questions which were aligned with questions in the EMS 1.0 survey. 115 interns participated this survey. The survey was anonymously completed and the responses were not linked to the interview data described below.

Table 1 provides an overview of the distribution of survey respondents from the EMS sample and the Large Engineering Company with regards to gender and underrepresented minority (URM) status. URM status in engineering was determined by using a "mark all that apply" question where respondents identified being American Indian or Alaskan Native, Black or African American, Hispanic or Latino/a, Native Hawaiian or Pacific Islander either independently or in combination with any other response options (also including Asian or Asian American, White, or Other). In both survey datasets, the students were rising juniors, seniors, or fifth year seniors. In a few cases, some of the engineering company interns had already graduated from their undergraduate studies and were preparing to enter their first year of graduate school.

Table 1: Gender and URM Status of the Engineering Majors Survey (EMS) and Large Engineering Company Survey Respondents

		EMS N=3235		***Large Engineering Company N=115***	
Gender		**N**	**%**	**N**	**%**
	Females	965	29.8%	22	19.1%
	Males	2027	62.7%	83	72.2%
	Missing	243	7.5%	10	8.7%
Underrepresented Racial/Ethnic Minority (URM)		**N**	**%**	**N**	**%**
	Not URM	2650	81.9%	94	81.7%
	URM	295	9.1%	9	7.8%
	Missing	290	9.0%	12	10.4%

Description of Variables for EMS and Engineering Company Surveys

Each of the following five measures are described in greater detail in [7].

<u>Innovation Self-Efficacy</u>: 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)

<u>Engineering Task Self-Efficacy</u>: 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.

<u>Innovation Interests</u>: 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).

<u>Career Goals: Innovative Work</u>: Measures the importance of one's aspirations to be involved in multiple phases or facets of "innovation work" in their careers and consists of the average of the average of six items, each measured on a five-point Likert scale from "Not important" (0) to "Very important (4).

<u>Post- Graduation Career Options</u>: Measures "How likely is it that you will do each of the following in the first five years after you graduate?" based on the nine options outlined in Table 3. Respondents were asked to rate each of the seven to eight career options on a five-point Likert scale of "Definitely will not" (0), "Probably will not" (1), Might or Might Not" (2), "Probably will" (3), and "Definitely will" (4).

C. *Large Engineering Company Intern Interview Dataset*

In the fall of 2017, semi-structured interviews of 20 students who completed a summer internship in the product development division at a large engineering company, during the period from May to August 2017, were conducted. The student interns ranged from rising juniors to master's students at universities from across the country from various engineering majors. Demographic information of the students was not explicitly collected, however the sample was approximately evenly divided between men and women.

Interns were recruited to participate in the interview by email invitation from the Director of Human Resources in the Product Development division. The purpose of the interview was to learn more about the interns' journeys at the company and their day to day work. Design methodologies were employed to understand the interns' perceptions of how much creativity was possible in their work assignment and their interactions with various people in order to gather insights about the organizational ecology of their work environment [9]. While all of the interns worked in product development, their internship assignments varied in level of technical focus, from projects focused on electronics and programming to project management.

The audio interviews were conducted over the phone and lasted approximately 30-45 minutes. These interviews were recorded and later transcribed. Each interviewee received a $20 Amazon gift card in appreciation for their participation. Excerpts of student responses from the transcripts of each interview were coded thematically and common trends across the responses were identified.

III. Results

A. *Quantitative Results*

Table 2 compares the mean responses and the related Cronbach's Alphas for the four scales – innovation self-efficacy, engineering task self-efficacy, innovation interests, and career goals: innovative work – for both the EMS and Engineering Company participants. The Cronbach's alpha is a test of internal consistency and represents the extent to which the items in a scale can be treated as measuring the same latent construct (such as motivation). Generally speaking, Cronbach's alphas of .6 and higher are considered acceptable levels of internal consistency, this threshold is arbitrary and an alpha value of .7 or above is preferable. The mean scores reported for the Engineering Company interns were consistently higher than the EMS students.

Table 2: Self-Efficacy and Innovation-related Scales for Engineering Majors Survey (EMS) and Large Engineering Company Survey Respondents

		Mean (SD)	**α**	**N**
Innovation Self-Efficacy	EMS	2.72 (.69)	.76	3079
	Engr. Co.	3.15 (.60)	.81	109
Engineering Task Self-Efficacy	EMS	2.54 (.79)	.86	3080
	Engr. Co.	3.03 (.68)	.87	80
Innovation Interests	EMS	2.40 (.74)	.76	3074
	Engr. Co.	2.90 (.62)	.75	107
Career Goals: Innovative Work	EMS	2.54 (.76)	.84	3016
	Engr. Co.	2.83 (.77)	.85	105

In Table 3, of the eight post-graduation career options related to industry, two-thirds of the EMS respondents and three-quarters of the Engineering Company respondents indicated they would probably or definitely will work as an employee for a medium- or large-size business.

Almost twice as many of the EMS respondents report that they probably/definitely will work for a small business or start-up and a much stronger interest in working for the government, military of public agency as compared to the Engineering Company respondents (21% vs. 6%).

Table 3: Likelihood of Post-Graduation Career Options for Engineering Majors Survey and Large Engineering Company Survey Respondents

	EMS Probably/ Definitely Will N (%)	**Engineering Company** Probably/ Definitely Will N (%)
Work as an employee for a small business or start-up company	1416 (26.0%)	11 (11.2%)
Work as an employee for a medium- or large-size business	4033 (65.0%)	79 (76.0%)
Work as an employee for a non-profit organization	658 (10.6%)	7 (8.8%)
Work as an employee for the government, military, or public agency	1301 (21.0%)	5 (6.0%)
Found or start your own for-profit organization	784 (12.6%)	9 (11.7%)
Found or start your own non-profit organization	357 (5.7%)	7 (10.3%)
Enter graduate school in an engineering field	---	49 (53.2%)
Enter graduate school in a non-engineering field	---	26 (31.8%)
Enter graduate school	2640 (42.6%)	---

B. *Qualitative Results*

While the survey data focused on the attitudes and perceptions of engaging in innovative work, the interviews exposed interns' engagement with creativity in their actual summer assignment. Coding of the qualitative interviews with an emphasis on understanding the opportunities for creativity in internship work assignments revealed a spectrum of perceptions. About half of the interns did not necessarily see an approach or even a need for creativity since most of the tasks were about engineering testing or building upon a previous model.

So, I didn't do a whole lot in coming up with my own work assignment. Now when it came to the projects that I did for my work assignment, there wasn't…there wasn't a whole lot of creativity. Honestly, as a product development engineer, you're trying to develop things so that they don't break or they don't have issues. You are trying to innovate in some cases, but especially on a three-month project as an intern, there *isn't a whole lot of room for innovation or creativity. Generally, it's a whole lot of things that just need to get done.*

So, not…not a whole lot of creativity, really. I basically had a workflow already set of things that needed to happen, so I would collect some data, make some conclusions, and then present them to the group. So, there wasn't a whole lot of creativity there. Now, there was, I don't know, there was quite a bit of high-level thinking that needed to happen for some of them. So, I had those conversations. But as far as just plain-and-simple creativity or any kind of artistic flair, there really wasn't.

…my intern position, that there was…it was pretty narrow, the job function. So, the creativity wasn't so much there as in my past co-op. When I was in the manufacturing co-op, I had a lot more creativity in being able to work on my own and kind of just innovate new processes.

The other half were given more freedom to expand upon their project assignment. The conditions that appeared to contribute to creativity and innovation in fairly narrowly defined, time limited summer work assignments was in many ways, a sense of ownership and encouragement to explore.

Oh, I had like full rein of what I wanted to do. My supervisor was kind of hands-off. She wanted me to explore what I thought was interesting, so she just gave me, "Yes, just look at smart materials that possibly have an application… and whichever you find most interesting, just let me know and you can further explore that." So, I was just like, wow, this is amazing!

Not a huge amount, unfortunately. There has been…I think I've kind of…I was given some projects, and I expanded…I expanded the scope of them a little bit to allow myself to be more creative…And so, I've had to search in some ways to find creativity, but the times when I've been able to be creative, I've enjoyed it a lot more than other times.

There was creativity in figuring out who to talk to and how to get people to cooperate with me. There was creativity involved in thinking of new ways to gather information.

Several of the interns interviewed mentioned the need to come up with creative solutions and approaches, typically through talking with others and figuring out how to navigate the organization. For the organizational ecology interview questions, the responses were coded the responses into eight categories of people:

- Managers
- Supervisor
- Other interns
- Former interns who now work at the organization
- Mentors
- Specialists (i.e. technical experts or design experts)
- Friends
- Other Colleagues

The total number of people each intern felt comfortable reaching out to for each question was captured. For example,18 of the 20 interns reported that they expected to stay in touch with at least two or more people beyond the summer. Conversely 12 interns felt comfortable reaching out to only one person to talk to about navigating an issue with a teammate (most often their supervisor).

An interesting pattern emerged around the prompt, *who would you approach to learn about full-time work at Ford?* Eight interns felt comfortable reaching out to only one person, while nine felt comfortable reaching out to four or more people.

The interview findings around the role of interns and how they learn to navigate an engineering company suggest that some interns prefer to find a single trusted source while others "explore" by engaging with many different people. In fact, this notion of trusting a small group versus exploring is a dichotomy of behaviors we will look at more deeply across these data and in future work.

IV. Discussion and Implications

These preliminary analyses of the EMS and the Engineering Company surveys highlight some potential directions for future exploration around the relationships between internship experiences and entrepreneurship-related outcomes and future career choices and plans. More generally, being exposed to an engineering environment and culture in industry rather than an academic culture appears to heighten students' innovation self-efficacy, engineering task self-efficacy, innovation interests, and career goals around innovative work. In addition, the "real world" setting and may also influence and contribute to their choice of career pathways. This initial investigation into the role of key members in the organizational ecology and opportunities for creativity in both the work assignments and daily activities of interns within the context of their pre-internship expectations and own professional goals serve to highlight areas where additional investigation is needed and also where qualitative perspectives and mixed methods approaches are particularly valuable.

Collectively, the results from this ongoing research provide a more nuanced and actionable understanding of the role of engineering internships for students wishing to apply their academic learning and make the most out of short-term industry experience in order to make thoughtful decisions about their postgraduate career pathways. In turn, these findings will also be informative to colleges and universities, particularly for faculty and staff who work directly with students and want to better prepare and support students in their transition to working outside of academia. Finally, this work can also assist industry partners, who are looking to innovate, transform and grow by providing insights into how to design of an engaging and compelling internship experiences for students and potential future employees.

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