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Exploring How Engineering Internships and Undergraduate Research Experiences Inform and Influence College Students' Career Decisions and Future Plans

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Abstract

Does engagement in high impact practices such as technical internships and undergraduate research influence engineering students' career decisions and future plans? And how is learning that comes from these high impact practices related to "school learning"? These high impact educational practices have been shown to increase the rates of student engagement and retention in higher education. While access to and participation in these activities is often unsystematic across various institutions, these practices have been shown to benefit college students with diverse backgrounds and learner qualities. This paper establishes a context for understanding the characteristics and attitudes of students who participate in internships and undergraduate research by drawing from analyses of the first administration of the Engineering Majors Survey (EMS), a longitudinal study designed to examine engineering students' career objectives related to creativity and innovation, and the experiences and attitudes that might influence those goals. In addition, using interview data from product development interns at a single engineering firm, we add insights into the specific skills that interns identify as learning in their internship and suggest connections between school-and-work learning. The more general picture of the impact of internship and research experiences (from the EMS), complemented with a "deep dive" into the learning that happens in internship experiences (from the interviews) provides a solid starting point for future exploration of how high impact practices such as internships and research experiences might be better integrated into a student's educational development.

Introduction and Background

Both undergraduate research and internships have been long recognized as critical high impact practices (HIPs) based on the research findings from the National Survey of Student Engagement (NSSE) [1]. The effectiveness of these high-impact activities can be attributed to several reasons including: 1) the significant amount of time and effort students invest in the tasks and activities; 2) engaging in an activity that requires that students interact with faculty, employers, and peers about critical matters, over an extended period of time, and 3) exposure to diversity through interactions with people from different backgrounds and also in a variety of work settings and environments [2], [3]. Collectively, these interactions and experiences can inform and influence decisions regarding post-graduation careers.

While there is a significant body of literature on both undergraduate research and internships broadly defined across different majors, there are fewer studies on the specific experiences of engineering students and correspondingly, student experiences of engineering-focused work in an internship, research, and co-op. For engineering students, participation in undergraduate research has often been facilitated through institutional initiatives as well as support at the national level through National Science Foundation funded Research Experiences for Undergraduates (REU) programs. Students may engage in research either during the school year or in the summers.

Internships also are often critical components of the undergraduate engineering trajectory. 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." [4]. Internships together with co-ops and other kinds of experiential learning opportunities serve to allow students to apply what they have learned in the classroom in a real-world context.

Furthermore, although internships, co-ops, and summer research are distinct experiences, they may provide similar growth and learning opportunities; nevertheless, they are often grouped together in the literature for statistical analyses (e.g., [5], [6], [7], [8]). This has limitations since even within the same internship program, students may have vastly different experiences dependent on their skill level, work assignment, coworkers, etc. These differences in experiences are amplified when students across majors in STEM, participating in different internship programs are grouped together. Within a specific major, students could participate in internships in vastly different fields, with different functionality. For example, one mechanical engineering student could complete a reliability engineering internship, whereas another could complete a business internship. It is difficult to draw conclusions on what types of internships might be the most impactful and in what ways when there is large variation in the internship experience that are not considered. Below we provide a brief sampling of some of the literature relevant to internship/co-op/research experiences of engineering students.

Engineering Internships

While the impact of internships/co-ops/research on undergraduate students in STEM has been researched extensively, internships in the engineering discipline specifically are not as thoroughly explored. In engineering, undergraduate seniors most often cite work-related activities (co-op, internship, employment) as a source of engineering knowledge, above personal contacts and school-related resources. 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 [8].

Engineering Co-ops

Cooperative education or co-op experiences generally last for more than one semester where students may alternate work terms with school semesters and receive academic credit for the work experience. Co-ops are often joint ventures between the university, employer, and student and provide companies with opportunities to identify and develop relationships with skilled talent and possible future employees.

The examinations of cooperative education conducted by [9], [10] recognized the value of co-op experiences to students' overall academic success as demonstrated in students' motivations as well as making connections between their classroom work and experiences in industry.

Even taking into account pre-work GPA, additional work experiences such as those acquired in co-ops was correlated with $1,471 higher post-graduation starting salary on average, increased likelihood of a job offer prior to graduation, and higher GPA upon graduation by 0.02 points for engineering students [7]. [10] similarly found that students in engineering majors who participated in a co-op program had a higher GPA and earned a higher salary upon graduation, and the gains from subject-specific work experiences increase with the length of the engagement. However, co-op students took about two semesters longer to complete their BS degree [10].

[11] showed that the impact of engineering co-ops was influenced by the following factors: whether or not the co-op made a difference in the organization, whether the student worked in a team, and whether the co-op applied knowledge from the student's major significantly predicted work self-efficacy. Further, co-op and internship students experienced a significant increase in their work self-efficacy[1] from their sophomore to senior year, whereas non-co-op/intern students experienced a decrease [11].

Engineering Research

Research experiences provide students the opportunity to form relationships with professors and graduate students, learn how to conduct research, and be exposed to graduate education and/or research-based careers. These experiences can take a variety of forms, from a structured REU program with a specific cohort to an individually designed experience. Typically the research experience occurs in a school's research lab, however students may also participate in research internships in industry or national laboratories as well.

In a survey of 651 alumni from the College of Engineering at the University of Delaware, [12] showed that engineering alumni who participated in undergraduate research were much more likely to pursue a graduate degree. Of the students who participated in the university's structured undergraduate research program, over 80% of the respondents had completed or were currently enrolled in graduate school, compared to less than 50% of the students who did not participate in research. Some 53% of the students who participated in the school's undergraduate research program indicated their participation in research was "extremely" or "very" important in their decision to attend graduate school. Notably, 87% of the respondents who pursued a doctoral degree had participated in undergraduate research. Respondents reported the highest overall benefit from undergraduate activities was participation in an internship, followed by involvement in undergraduate research [12].

There are also other student-reported impacts of research experience. In semi-structured interviews conducted by [13] with 76 rising seniors who were engaged in undergraduate summer research, students reported both negative and positive gains from the experiences. Positive research experiences reinforced existing career-related goals, while at the same time enhancing their resumes, professional network and career-related experience in preparation for future careers. In contrast, negative experiences (such as mechanical tasks, lack of direction, and poor mentors) caused some students to change career or education plans [13]. Research experiences also seem to clarify and confirm students' pre-existing career directions, and even for the few students (seven seniors) who found that research careers were not for them, the discovery was reported as a "gain" not a negative since it still helped clarify future career plans [14].

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[1] [11] defined work self-efficacy as the students' beliefs in their command of the social requirements necessary to succeed in the workplace

Guiding Research Questions

The current study aims to: 1) investigate relationships between engineering students' future career goals and their participation in internships and/or research; and 2) gain qualitative insights into the summer experiences of engineering majors interning at a large Fortune 500 company. This globally distributed company employs about 25,000 engineers representing nearly all engineering majors.

RQ1: How does engagement in undergraduate research and internship experiences affect students' post-graduation plans in engineering?

RQ2: How do engineering majors interning at a large engineering company view their learning before, during, and after the internship?

Methods

This study used a mixed methods approach to analyzing two independent data sets. One set consists of quantitative survey data and the other qualitative structured interview data.

Engineering Majors Survey

The Engineering Majors Survey 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 [15], [16].

The EMS 1.0 dataset used for this study included 6,187 junior and seniors. Table 1 provides an overview of the distribution of survey respondents with regards to students' current progress in studies, gender and underrepresented minority (URM) status. URM status in engineering was defined 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).

Table 1: Description of the Engineering Majors Survey Respondents

Variables	***N***	***Percent***
Current academic standing		
Juniors	2890	46.7%
Seniors + Fifth-year seniors	3297	53.3%

Variables	***N***	***Percent***
Gender		
Females	1611	26.0%
Males	3731	60.3%
Missing	845	13.7%
Underrepresented Racial/Ethnic Minority (URM)		
Not URM	4532	73.3%
URM	703	11.4%
Missing	952	15.4%

The survey also asked students whether they had undergraduate research and internship experiences. Respondents selected "yes" (1), "no" (0), or "I prefer not to answer" (-9) to indicate their answers in two survey items:

While an undergraduate, have you done (or are you currently doing) each of the following for at least one full academic or summer term?

1. Conduct research with a faculty member
2. Work in a professional engineering environment as an intern/co-op

With answers to these two questions for the 6,187 EMS Juniors and Seniors four distinct groups with regards to internship and research experiences can be created, as shown in Table 2. These four groups allow us to consider whether having multiple high impact experiences has an influence on persistence and success (as suggested by [17]). Noteworthy (and as expected), the results of the chi-square test found a statistically significant relationship between type of research/internship engagement and academic standing ($\chi^2(3, N = 5797) = 306.44, p < .001$); there is a greater proportion of seniors with some kind of internship experience (Groups 2 and 3) as compared to the juniors (Group 4).

Table 2: Typology of Research and Internship Engagement by Academic Standing

Variables	Group 1: Research Only and No Internship N (%)	Group 2: Internship Only and No Research N (%)	Group 3: Both Research and Internship N (%)	Group 4: No Research and No Internship N (%)	
Total	726 (12.5%)	2122 (36.6%)	1107 (19.1%)	1842 (31.8%)	(100%)
Juniors	374 (13.8%)	844 (31.3%)	351 (13.0%)	1130 (41.9%)	(100%)
Seniors	352 (11.4%)	1278 (41.3%)	756 (24.4%)	712 (23.0%)	(100%)

As a primary focus of the analyses for this paper was on future engineering plans two other EMS questions were important. In the first, respondents were asked to estimate the likelihood of their work "involving engineering, e.g., engineering practice, research, management, or sales" in the future – the "first year after you graduate", "five years after you graduate", and "ten years after you graduate". The Likert scale options included "Definitely will not" (0), "Probably will not" (1), Might or Might Not" (2), "Probably will" (3), and "Definitely will" (4).

The second EMS question asked respondents: "How likely is it that you will do each of the following in the first five years after you graduate?" Respondents were asked to rate each of the eight career options on a similar five point Likert scale:

A. Work as an employee for a small business or start-up company
B. Work as an employee for a medium- or large-size business
C. Work as an employee for a non-profit organization
D. Work as an employee for the government, military, or public agency (excluding a school or college/university)
E. Work as a teacher or educational professional in a K-12 school
F. Work as a faculty member or educational professional in a college or university
G. Found or start your own for-profit organization
H. Found or start your own non-profit organization

Large Engineering Company Intern Interviews

In Fall 2017, semi-structured interviews with 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 about 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' journey at the company, get their feedback with the intent of improving the internship experience, and to better understand the transition process between an academic setting to a corporate environment. While all 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 as a thank you for their time and participation. A coding scheme was developed and applied by thematically coding excerpts of student responses from each interview transcripts and identifying common trends across the responses.

A primary focus of the qualitative analyses was to explore the interns' perceptions about the development and acquisition of engineering knowledge, skills, and abilities (KSAs) necessary to succeed in their internships. The findings are based on three interview questions:

1. Were there engineering skills that you had to "learn on the job"? If so, what were they?
2. Knowing what you know now, what knowledge or skills do you wish you had at the start of your internship?
3. Skills may come from a variety of places, such as clubs or other activities, have any extracurricular or experiential learning activities helped you in your internship? If yes, how?

Results

RQ1: How does engagement in undergraduate research and internship experiences affect students' post-graduation plans in engineering?

Students' interest in staying involved in engineering 1 to 5 years out, by Research & Internship Engagement Group, is summarized in Table 3. Across all four groups, we found that students' expectations were similar for both the first year and the five years after graduation. In both these time periods, one-way analyses of variances (ANOVAs) revealed statistically significant differences among the groups. Tukey post hoc tests showed that students who participated in both internships and research experiences (Group 3) reported significantly higher means than students who participated in neither (Group 4) and those who were only involved in research (Group 1). Noteworthy is that the two groups with internship experience (Groups 2 and 3) were not statistically different from one another in their commitment to engineering 1-5 years out.

Table 3: Future Engineering Plans by Typology of Research and Internship Engagement

Variables *Involvement in engineering work in:*	Group 1: Research Only and No Internship M(SD)	Group 2: Internship Only and No Research M(SD)	Group 3: Both Research and Internship M(SD)	Group 4: No Research and No Internship M(SD)	F Statistic
1 Year	3.17 (.98)^{ab}	3.49 (.77)^{ac}	3.50 (.80)^{bd}	3.10 (.93)^{cd}	F(3,5358) = 85.44***
5 Years	3.19 (.90)^{ab}	3.42 (.74)^{ac}	3.38 (.77)^{bd}	3.27 (.83)^{cd}	F(3,5357) = 19.01***

$^{***}p<.001$ $^{**}p<.01$ $^{*}p<.05$
Scale options: "Definitely will not" (0), "Probably will not" (1), Might or Might Not" (2), "Probably will" (3), and "Definitely will" (4)
[a] Group 2 > Group 1***
[b] Group 3 > Group 1***
[c] Group 2 > Group 4***
[d] Group 3 > Group 4**

In Table 4, of the eight career options presented in the Engineering Major Survey, working as an employee for a medium- or large-size business was the most desirable across all four groups, reporting means ranging from 2.43 to 2.89 (*Might or Might Not* to *Probably Will*). The second and third most often cited options were working as an employee for a small business or start-up company and then, for the government or public agency. Working in the non-profit sector was seen to be only slightly more desirable than founding or starting a for-profit company. Becoming a faculty member was not very desirable overall but had greater appeal for students who had participated in research (Group 1).

Table 4: Likelihood of Post-Graduation Career Pathways by Typology of Research and Internship Engagement

Variables	Group 1: Research Only & No Internship M(SD)	Group 2: Internship Only & No Research M(SD)	Group 3: Both Research & Internship M(SD)	Group 4: No Research & No Internship M(SD)	F Statistic
Work as an employee for a medium- or large-size business	2.43 (.85)^{abc}	2.89 (.78)^{ade}	2.77 (.88)^{bdf}	2.64 (.76)^{cef}	$F(3,5355) = 64.40^{***}$
Work as an employee for a small business or start-up company	1.94 (.88)^{c}	1.92 (.94)^{gh}	2.05 (.96)^{gi}	2.09 (.85)^{chi}	$F(3,5352) = 12.66^{***}$
Work as an employee for the government, military, or public agency	1.70 (1.01)^{c}	1.64 (1.00)^{h}	1.63 (.99)^{i}	1.93 (1.03)^{chi}	$F(3,5351) = 29.95^{***}$
Work as an employee for a non-profit organization	1.48 (.92)^{j}	1.25 (.87)^{ghj}	1.37 (.93)^{gi}	1.47 (.90)^{hi}	$F(3,5353) = 22.56^{***}$
Found or start your own for-profit organization	1.23 (1.01)^{b}	1.20 (1.02)^{g}	1.40 (1.07)^{bfg}	1.28 (1.07)^{f}	$F(3,5349) = 8.01^{***}$
Work as a faculty member or educational professional in a college or university	1.13 (1.08)^{jk}	.72 (.81)^{ghj}	1.05 (1.02)^{fg}	.92 (.91)^{fhk}	$F(3,5354) = 47.71^{***}$
Found or start your own non-profit organization	.96 (.91)	.86 (.86)^{gh}	1.03 (.94)^{g}	.95 (.93)^{h}	$F(3,5350) = 8.58^{***}$
Work as a teacher or educational professional in a K-12 school	.67 (.85)^{j}	.51 (.75)^{ghj}	.62 (.81)^{g}	.65 (.85)^{h}	$F(3,5354) = 12.27^{***}$

$^{***}p<.001$ $^{**}p<.01$ $^{*}p<.05$

Scale options: "Definitely will not" (0), "Probably will not" (1), Might or Might Not" (2), "Probably will" (3), and "Definitely will" (4)
[a] Group 1 < Group 2
[b] Group 1 < Group 3
[c] Group 1 < Group 4
[d] Group 3 < Group 2
[e] Group 4 < Group 2
[f] Group 4 < Group 3
[g] Group 2 < Group 3
[h] Group 2 < Group 4
[i] Group 3 < Group 4
[j] Group 2 < Group 1
[k] Group 4 < Group 1

Looking more specifically at the responses of students who participated in Research only (Group 1) and Internships only (Group 2), student with exposure to the workplace were more committed to engineering (Table 3) and to working in a medium or large-size company. In contrast, students with only research experience were reported a higher likelihood of working in a college or university environment. Students with no exposure to internships and research (Group 4) were significantly more committed to working for a small business or start-up (Mean = 2.09) or for the government or public agency (Mean = 1.93) as compared to the other three groups. Students who had both internship and research experience (Group 3) also reported a significantly higher likelihood of founding or starting a for-profit organization as compared to the other three groups.

It is also instructive to look at differences in career pathways between those who only report internship experience and no research experience (Group 2) and those with both internship and research experiences (Group 3). In six of the eight career options, those in Group 3 express more interest than those in Group 2. While some of these interest levels are notably low (e.g., 1.03 for "found or start your own non-profit organization"), it does suggest that individuals in these two groups may be thinking differently regarding the range of career possibilities.

RQ2: How do engineering majors interning at a large engineering company view their learning before, during, and after their internship?

The EMS data, as presented above, have allowed us to illustrate the impact of internship and/or research experiences on commitment to engineering and thinking about future career plans. But what is actually happening in those experiences? Our second research question explores this, looking specifically at the internship experience as related to engineering skills used as part of the internship experience. Our interview protocol focused on "engineering skills" in terms of which skills were needed and which skills students learned on the job. We intentionally left "engineering skills" open to the students' personal interpretations. Almost all of students considered professional, personal, and technical aspects in their definitions of "engineering skills" in their responses. Here is what we heard from these 20 interns:

Learning on the job: The two main skills they highlighted were learning new software tools (e.g., programming, CAD, CAE) and learning how to work in a professional environment, which included professional communication, collaborating with different people, and learning how a large for-profit organization operates. Additionally, for several students this internship was their first experience with large systems engineering, since classroom experiences often focus on subcomponents:

> *"I didn't even know what a powertrain consisted of before I got there, so I did some Googling like right before I started. So, even just learning how a car worked in general, so I could understand what was happening when I was running models, was really important.*

> *And then, the software, I was using the [name of software tool] to build my models, and I had had some experience with it. I knew basics, like I could import models and save things, and even run things just off the computer, but learning how to move components, and adding things in, and just like meshing two models together, even just meshing a part was a lot harder than I thought it was going to be. So, pretty much everything that I had to do with that software I learned on-the-job, which was both fun and frustrating at times."*

Only a few students mentioned they had to learn engineering theory in more depth, such as a student who had to learn about Insulated Gate Bipolar Transistors (IGBT):

> *"I was learning the engineering theory behind IGBT devices, is what they're called. So, basically just advanced signal processing techniques and advanced power electronics circuit design. I mean, a lot of it was general circuit tracing that I was able to study and follow, but learning the theory behind these grad school level tests, it was…that's where I was learning like: Okay, this is where switching losses are happening. When we're taking a look at a waveform, why are these slight slopes happening? It's just through different types of losses. And you're learning throughout the circuitry and how stuff is designed in that regard, that nothing is ideal, obviously, and how those slight abnormalities in the data really can affect; so, how the group was modulating their tests to make it…to account for those slight differentials."*

Crucially, this student also highlighted that his internship gave him the opportunity to understand the limitations of theoretical classroom learnings in practical engineering work. In addition to technical skills, the majority of students described the personal skills they had to learn and practice during the internship:

> *"A lot of it has been learning how to conduct myself in a business environment. I mean, being professional is not difficult, really, you're just polite, and at other times you need to be more straightforward and kind of harsh with getting people to get things done. But learning about confidentiality and the power of putting your words in writing.... And then also just classic bureaucracy things, having to get approval from five different people to get anything done has been challenging, but I've also just learned that that's…that's part of working for a big company, and they have to have fail safes like that in place to make sure people aren't abusing opportunities that the company affords, like their company paying for parts they need to order."*

The students did not feel like learning these skills on the job was a burden. Rather, they felt that learning was a natural component of an internship in engineering. The students were content with their skill level and university preparation before the internship. Two students summarized this sentiment:

> *"I personally feel that being able to learn on-the-job is a strong talent, something strong. And, you know, I could say a bunch of things, like I wish I knew all the programming languages, I wish I had all the documentation, but, you know, I think being…learning the skill – I guess maybe that's it – I was…I wish I knew how to learn better, you know. So, that's something that I wish, yeah, I think it's a strong skill that only real job experience can teach,*

because learning from a book at school is one thing, but learning from a web page article or some document someone else wrote is a whole new…whole different beast. And it's probably one of the most important things to add worth."

"I would have wished to have a better understanding of the timeline of how things work here at [the company], and to have been able to use that timeline to organize myself a little bit better. I found myself often needing someone at a week when they were on vacation or something like that, and that added a lot of extra challenges to the project that I could have avoided if I had known more about the timeline for things. But, honestly, there's just so much to learn, and it makes sense that I didn't know some of those things coming in as an intern. So, I don't think…I think when I arrived here, my supervisor had a packet of information for me to review over my first week. He was very prepared, and even though I did not know everything I needed for my internship, I was able to pick up what I needed quickly."

Learning before the internship: In an ideal situation, many students wished they had learned more programming. They had a fundamental understanding of programming before starting the internship, but wished they had more pre-internship experience with large-scale programs:

"Definitely more coding experience would have been nice. I had done some MATLAB coding, but definitely I was on a steep learning curve initially, trying to figure out the best way to go about it. And, going back, I'm sure I'd code it slightly differently, just based what I learned along the way. Besides that, though, I felt like it was a good match of they kind of knew my experience and knowledge level and they put me in an appropriate group."

Many students also wished they had practiced more personal skills (as related to, for example, persuasion, organization, technical communication) before the start of the internship, as well as project management related skills such as budgeting:

"I think I wish I was a little better at communicating technical ideas. Like I think I'm fine at answering these types of questions, but presenting data to my boss or showing him what I've been doing, it felt kind of hard. I don't know why, or I don't know if I'm just nervous, but I think I've…I'm technically doing well, but I think I could be better at communicating what I just did."

"So, I would say, again, how to work with a budget. Just…I know this is probably classic, but communication. It's…I really do believe now that it is…it is the make-or-break when working on a team or working on a project of any sort. Continuing to work on those skills, and in many formats, too, not just written. Even in a meeting type setting, how to conduct yourself. I'd say those would be two skills that I wish I had seen more of before taking on the internship."

Extracurricular learning that contributed to internship success: The students were able to draw from a range of extracurricular activities to succeed in the internships. Some students spent many hours in school-based engineering teams with practical, real world applications, such as their school's hyperloop team, Eco Car team, Formula SAE team, and capstone design projects. From these hands-on engineering experiences they were exposed to industry standards and culture, learned about system integration, project management, documentation, and working with groups of people.

> *"Formula SAE, probably nothing would have better prepared me for working at [the company]. Because working on that team, you essentially design a vehicle from scratch, from the ground up. So, I learned CAD software right away, learned how to manufacture different parts. And I've been on a team for four years now, so initially you just learn kind of manufacturing, like a mill or a lathe, and then you start to learn vehicle dynamics fundamentals and why the car is built how it is, things like that. And then, your second, third, and fourth year, you actually are working on designing the vehicle and improving it. And it's kind of interesting because it's a small company, almost; we've got 28 team members on the team. So, we hold…we hold weekly meetings about the design aspect of the vehicle, and then also a team management meeting, also a different day, like obtaining sponsors, what events are going on, if we have to bring the car to school for something…for some event, or recruiting, things like that. ...We're doing that right now, recruiting new members. So, it's kind of like you're working for a small company. And I've spent…there's plenty of times where I've spent like 40-60 hours a week at the club working on the car and trying to improve it and things like that."*

One student in Formula SAE went so far as to say, *"Everything I learned there is what I use in my internships. I have yet to use anything from class at any of my internships, it's all been stuff that I've done on the team."* (116)

Students also participated in extracurriculars such as sororities, honors societies, athletics, tutoring/teaching, from which they developed skills in leadership, "small talk", developing team culture, communication, and working in high stress environments.

> *"Rowing certainly had a profound impact in my life. I mean, I was doing it like 30 hours a week all through college, and I bonded with a group of people in a way that I don't think a lot of other people get a chance to do…. We finished 18th one year, which is abysmal for us, and we just decided: Let's try to implement a strategy of culture change and acceptance and encouraging each other and design a group of people to operate in a way that we think is going to help us perform the best. And it ended up working…It's given me a lot of confidence going forward in working at a job and having confidence that if I am put in a leadership role or if I find myself an opportunity to build a leadership role, you know, I can make a difference."*

> *"I worked at a high ropes course, and I would lead groups of students through. It's called a leadership challenge course, and it was all about fostering leadership and communication and all this other stuff in high-stress environments. And I think that's really empowered me, I guess not even in an internship standpoint but throughout my whole life in ways that I view leadership, in ways that I view how I work and how I evaluate myself. Like: pushing past comfort zones; like being able to take on more stressful situations; communicating with large groups of people; having hard conversations with people. I think that job specifically has really helped me kind of gain the experience I needed on a social level and really develop soft skills that have helped me communicate as a leader and as an employee."*

The knowledge, skills, and abilities cited in the qualitative interviews included personal skills, technical depth, and company-specific knowledge coming from a variety of academic experiences, extracurricular activities, and other internship and workplace-related contexts. While these interns came from a wide range of backgrounds/experiences going into the internship, the majority felt prepared for the tasks they were assigned. Generally speaking, interns understand that being able to learn on the job is important and they aren't expected to know everything beforehand.

Discussion and Implications

The typology of engagement with the high impact practices of undergraduate research and internships was created as an organizing framework for the findings related to our two research questions below.

RQ1: How does engagement in undergraduate research and internship experiences affect students' post-graduation plans in engineering?

Perhaps unsurprisingly, not all engineering undergraduates have internship and research experiences. While nearly two-thirds of the juniors and seniors we considered had had an internship, nearly one in four seniors had not had an internship or research experience. And yet exposure to research and internship experiences as an undergraduate engineering major does appear to have a positive impact on expectations of engaging in future work involving engineering both in the short term (i.e., the first year after graduation) and long term (i.e., the next five years after graduation). Higher expectations of ongoing engineering-related experiences were evidenced by the higher means of Groups 2 (Internship Only, No Research) and 3 (Both Internships and Research). We also point to [18] who illustrate the positive relationship of undergraduate research and internships on engineering related confidence, particularly on Engineering Task Self-Efficacy (ETSE) and URM women. Future research could explore the individual motivations and the environmental and institutional factors that influence whether or not students participate in these high impact practices.

Additional analyses examining the likelihood of eight future career paths reiterate the differential impact of varying exposure to either research or internships or to both kinds of experiences. Of particular interest are the groups that represent student involvement in both internships and research (Group 3) and those students who are involved in neither (Group 4), both as compared to the only research and no research or internship groups (Groups 1 and 4, respectively), and to one another. On this latter point, those in Group 3 seem to be more generally considering a variety of career paths. One possible interpretation is that those who had only internship experiences (those in Group 2) may have had more of these internship experiences than those in Group 3 and are therefore more certain about their career direction (so have eliminated some options). Another interpretation is that those in Group 3 (internship & research) have had their thinking broadened (relative to those in Group 2) as to the range of areas that can involve engineering. Unfortunately, our current data set does not allow us to do more than speculate on this finding. Future research could explore how internships and research experiences are distinct from one another, how they relate to individual students interests and motivations, and how best to advise students in thinking about extra-curriculum opportunities such as internship and research experiences.

RQ2: How do engineering majors interning at a large engineering company view their learning before, during, and after the internship?

Preliminary analyses of the 20 interviews conducted with engineering students who completed a summer internship at a large engineering company found that interns generally felt well-prepared academically for their internships. There was an understanding that some aspects of the internship would have to be learned on the job, but that their classroom experiences in their universities had provided sufficient foundation for the work assignments.

The analysis highlights the variety of places where engineering interns learn, both prior to arriving on the work site and during the internship. Relevant technical and professional and interpersonal knowledge, skills, and abilities are only acquired in a variety of contexts and environments prior to and within the work environment and inside and outside the classroom. The qualitative findings provide a snapshot into the engineering internship experience that can inform individuals and companies that hire interns as well as higher education institutions that prepare students to become interns. Understanding the transition from the academic environment to industry and in the case of internships, back to academia, is not only important for the current study but should continue to be an emphasis in ongoing research efforts.

Future work may take into consideration of what knowledge, skills, and abilities engineering students might gain from participating in other high impact practices such as study abroad, diversity/global learning, and capstone projects. Findings from [17] suggested that "participation in multiple high impact activities of different kinds provides greater benefit to students than participation in only one type" (p.5). A limitation to the current study is acknowledging that students who participate in internships/co-ops and research may be self-selecting and there may also be other factors (e.g., financial, family) that may constrain engineering students' ability to engage in these experiences. In addition, while the term "internship" is commonly recognized, more details about the specific nature of the assignment or project that the internship entails would provide a more accurate assessment of the impact of the experience on the student, how well-prepared he/she is, and the impact on the student's goals and future plans.

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Exploring How Engineering Internships and Undergraduate Research Experiences Inform and Influence College Students' Career Decisions and Future Plans

Kayla Powers, Helen L. Chen, K.V. Prasad, S.K. Gilmartin, & Sheri Sheppard

ASEE ◆ June 25, 2018

Cooperative and Experiential Education Division

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Stanford University

High Impact Practices (Kuh, 2008, 2018)

1. First-Year Seminars and Experiences
2. Common Intellectual Experiences
3. Learning Communities
4. Writing-Intensive Courses
5. Collaborative Assignments and Projects
6. **Undergraduate Research**
7. Diversity/Global Learning
8. Service Learning, Community-Based Learning
9. **Internships**
10. Capstone Courses and Projects
11. ePortfolios

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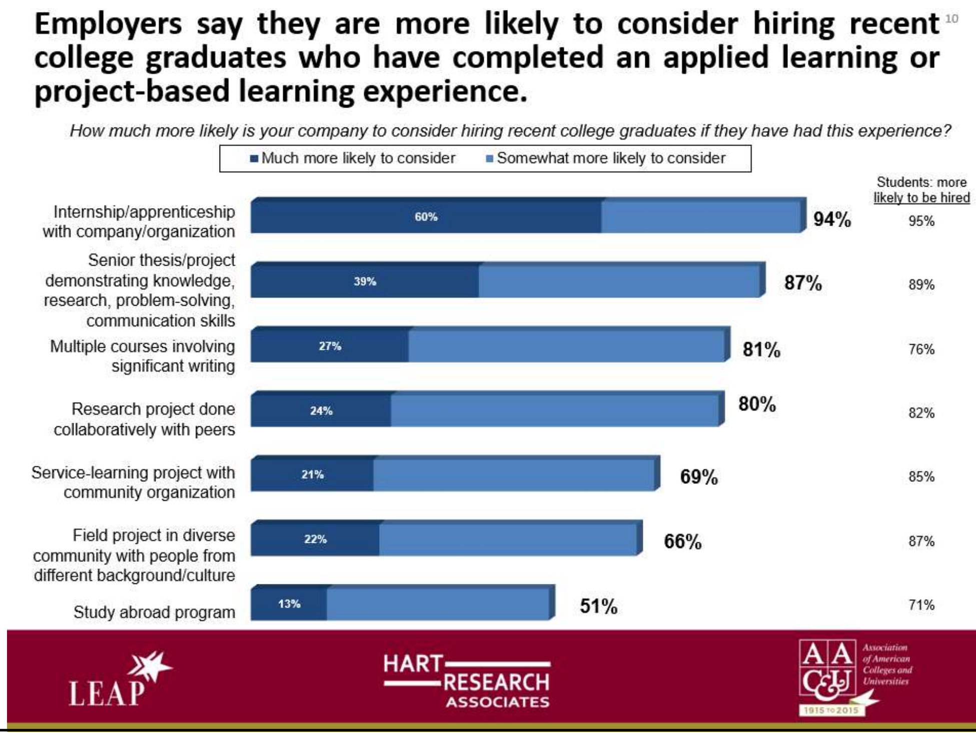

Key Attributes Employers Seek on a Resume

Problem-solving skills -82.9%

Ability to work in a team -82.9%

Communication skills (written) – 80.3%

Leadership – 72.6%

Strong work ethic – 68.4%

Analytical/quantitative skills – 67.5%

Communication skills (verbal) – 64.1$

Initiative – 60.7%

Detail-oriented – 59.8%

Flexibility/adaptability – 54.7%

Technical skills – 48.7%

Interpersonal skills (relates well to others) – 48.7%

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Exposure to engineering work via internships and co-ops

Undergraduate seniors most often cite work-related activities as a source of engineering knowledge, above personal contacts and school-related resources. *Sheppard et al. (2010)*

Co-op experiences contribute to students' overall success by increasing students' motivations and helping them make connections between their classroom work and industry experiences. *Blair et al. (2004), Blair & Fortenberry (2008)*

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Exposure to engineering work via undergraduate research

Engineering alumni from U Delaware (N=651) who participated in UG research were more likely to pursue a graduate degree *Zydney et al. (2002)*

Research experiences can clarify and confirm students' pre-existing career directions, even for students who decide that a research career is not for them *Seymour et al. (2004)*

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Guiding Research Questions

RQ1: How does engagement in undergraduate research and internship experiences affect students' post-graduation plans in engineering?

RQ2: How do engineering majors interning at a large engineering company view their learning before, during, and after the internship?

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Engineering Majors Survey – RQ1

Focused on engineering students' interests and career goals around I&E

Administered in Winter/Spring 2015 to a nationally representative sample of 27 U.S. engineering schools

N=6,187, 60% male, 12% URM, 47% jrs., 53% srs.

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Designing Career Pathways for Engineering Innovation – RQ2

- Two year collaboration aimed at studying the diverse career pathways of early career engineers
- Large Fortune 500 company employing 25,000 engineers representing nearly all engineering majors
- Year 1: understanding the experiences of the product development (PD) summer interns

How do internships help students make decisions about their post-graduate career pathways?

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Research Only/ No Internship (12.5%)	No Research/ No Internship (31.8%)
Research and Internship (19.1%)	Internship Only/No Research (36.6%)

Likelihood of future engineering plans involving engineering

	Research Only/ No Internship	Internship Only/No Research	Research and Internship	No Research/ No Internship	
1 Year	3.17 (.98)[ab]	3.49 (.77)[ac]	3.50 (.80)[bd]	3.10 (.93)[cd]	$F(3,5358) = 85.44^{***}$
5 Years	3.19 (.90)[ab]	3.42 (.74)[ac]	3.38 (.77)[bd]	3.27 (.83)[cd]	$F(3,5357) = 19.01^{***}$

$^{***}p<.001$ $^{**}p<.01$ $^{*}p<.05$
Scale options: "Definitely will not" (0), "Probably will not" (1), Might or Might Not" (2), "Probably will" (3), and "Definitely will" (4)

Likelihood of future engineering plans involving engineering

<

	Research Only/ No Internship	Internship Only/No Research	Research and Internship		
1 Year	3.17 (.98)[ab]	3.49 (.77)[ac]	3.50 (.80)[bd]	3.10 (.93)[cd]	$F(3,5358) = 85.44^{***}$
5 Years	3.19 (.90)[ab]	3.42 (.74)[ac]	3.38 (.77)[bd]	3.27 (.83)[cd]	$F(3,5357) = 19.01^{***}$

$^{***}p<.001$ $^{**}p<.01$ $^{*}p<.05$
Scale options: "Definitely will not" (0), "Probably will not" (1), Might or Might Not" (2), "Probably will" (3), and "Definitely will" (4)

Likelihood of future engineering plans involving engineering

		Internship Only/No Research	Research and Internship	> No Research/ No Internship	
1 Year	3.17 (.98)^{ab}	3.49 (.77)^{ac}	3.50 (.80)^{bd}	3.10 (.93)^{cd}	$F(3,5358) = 85.44^{***}$
5 Years	3.19 (.90)^{ab}	3.42 (.74)^{ac}	3.38 (.77)^{bd}	3.27 (.83)^{cd}	$F(3,5357) = 19.01^{***}$

$^{***}p<.001$ $^{**}p<.01$ $^{*}p<.05$
Scale options: “Definitely will not” (0), “Probably will not” (1), Might or Might Not” (2), “Probably will” (3), and “Definitely will” (4)

Engineering Company Intern Interviews

Conducted in Fall 2017 with 20 students who completed a summer internship in PD from May to August 2017

- *What engineering skills did you have to “learn on the job”?*
- *What extracurricular or experiential learning activities helped you in your internship?*

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What engineering skills did you have to "learn on the job"?

Technical Skills

- How a powertrain works
- Theory behind Insulated Gate Bipolar Transistors
- Learning new software tools (CAD, coding)

Professional Skills

- How to write an email
- How to navigate bureaucracy
- How to conduct oneself in a meeting
- How to work with different types of people

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What extracurricular or experiential learning activities helped you in your internship?

"I worked at a high ropes course, and I would lead groups of students through… It was all about fostering leadership and communication in high-stress environments. That job specifically has really helped me kind of gain the experience I needed on a social level and really develop soft skills that have helped me communicate as a leader and as an employee."

"Everything I learned [on the Formula SAE team] is what I use in my internships. I have yet to use anything from class at any of my internships, it's all been stuff that I've done on the team."

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Limitations

- What is an internship? Not all internship, co-op, and research experiences are the same.
- How are internships, co-ops, and research experiences distinct from each other?
- Students who participate in internships/co-ops and research may be self-selecting; what other constraints (e.g., financial, family) should be considered?

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Future Research Efforts

- How is the internship/co-op/research experience influenced by individual student interests and motivations?
- How do we better understand the transition from academia → industry → academia?
- What knowledge, skills, and abilities might students learn from other High Impact Practices (e.g., study abroad, capstones)?
- How can we share this research with internal and external stakeholders to inform curriculum/programming, policy, and practice?

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