Exploring Entrepreneurial Characteristics and Experiences of Engineering Alumni

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Abstract

In recent years one of the goals of the National Science Foundation (NSF) has been to encourage new generations of engineering students to become more entrepreneurially-minded and self-employed in the engineering field. Engineering schools in the United States have specific curricular requirements that students must fulfill in order to graduate, and some of these requirements may incorporate a component of entrepreneurship education. As part of the research reported here, data from a survey of recent engineering alumni were used to examine and determine which engineering graduates have an interest *and/or* intention towards entrepreneurship. Analyses related to the demographic characteristics, desired career outcomes and career satisfaction, and pre- and post-graduation undergraduate learning experiences, of these alumni were conducted. The research questions guiding this study are:

1) How might engineering alumni be characterized based on their levels of interest in and intention to pursue entrepreneurial activity?
2) What similarities and differences in desired career outcomes, career satisfaction, and undergraduate learning experiences exist among engineering alumni with varying levels of entrepreneurial interest and intention?

Introduction

Entrepreneurially-minded alumni are in high demand and have become a powerful force in driving the U.S. economy[13]. Moreover, entrepreneurs in the technology field are viewed as critical to the future success of the United States and its position as a global leader[1]. Many universities around the U.S. have begun to implement curricular and co-curricular programs in an attempt to influence and expose students to experiences that will foster entrepreneurial thinking. More research is being conducted to investigate the impact of these programmatic initiatives and identify what factors promote an entrepreneurial mindset.

In this study we investigate how both interest and intention have influenced engineering alumni towards entrepreneurship. With respect to entrepreneurial interest, Lent, Brown, Sheu, Schmidt, and Brenner[12] posited that a person's interest in a given activity is based on two concepts: 1) self-efficacy or beliefs about one's own personal capabilities; and 2) outcome expectations or beliefs about the outcomes of engaging in a particular course of action.

Entrepreneurial intention, was chosen because intentions are a critical predictor of any planned behavior, including entrepreneurship. Intention clarifies what are the triggers of opportunity scanning, such as where sources of ideas for a business venture come from, and how a venture ultimately becomes a reality[11]. Starting a business is an intentional act and strong intentions to start a business are likely to result in an eventual attempt[11].

We propose that alumni who have shown both high interest and high intention are more likely to pursue entrepreneurship, since intention in combination with interest will result in a higher likelihood of entrepreneurial action.

While several studies have identified factors that are associated with entrepreneurial interest *or* entrepreneurial intention among alumni, there is little research that analyzes both of these factors simultaneously. For instance, Yang, Eesley, Tian and Roberts[21] conducted a study of 3,646 alumni from Tsinghua University in China that evaluated the effects of the university's educational system on student's entrepreneurial intentions. Some of the main variables related to entrepreneurial intentions identified were: entrepreneurial capability, leadership, professional skills, and knowledge in entrepreneurship-related areas. However, this study does not consider entrepreneurial interest among their participants.

Wilson, Kickul, and Marlino[19] surveyed 4,292 adult Master of Business Administration (MBA) students and adolescents, in order to determine their level of interest in pursuing an entrepreneurial career. Entrepreneurial interest was measured by asking participants to rate their interest in starting or owning their own business but the study did not consider entrepreneurial intention.

It is critical that universities provide their students with opportunities for entrepreneurship training[1] in order to ultimately supply the workforce with professionals who are innovative team members and managers. This requires having a deeper understanding of the kinds of undergraduate experiences that are associated with highly innovative alumni and high levels of interest and intention in entrepreneurship. This paper describes analyses of engineering alumni from four geographically distributed institutions, and is guided by the following two research questions:

1. How might engineering alumni be characterized based on their levels of interest in and intention to pursue entrepreneurial activity?
2. What similarities and differences in desired career outcomes, career satisfaction, and undergraduate learning experiences exist among engineering alumni with varying levels of entrepreneurial interest and intention?

Description of Dataset

The Pathways of Engineering Alumni Research Survey (PEARS) was designed in the summer of 2011 as a component of the NSF-funded Engineering Pathways Study. Piloted with geographically distributed engineering alumni from four institutions in the fall of 2011, PEARS expanded upon the prior work of the Academic Pathways of People Learning Engineering Survey (APPLES) which was deployed to more than 4,500 undergraduate engineering students at 21 institutions[3,5,6].

The objectives of PEARS were to: 1) inform the field's understanding about how the college experience advances engineering students' development as early career professionals (ECPs) and their conceptions of and preparations for their specific careers; 2) identify the educational and workplace factors, or combinations of these factors, that most influence the development of engineering students into successful ECPs; and 3) illuminate the pathways of early ECPs in terms of planning and preparing to meet future career goals and overcome challenges[4].

Methodology

The PEARS instrument was an online survey administered to engineering graduates four years after earning their engineering bachelor's degrees in 2007. The graduates came from four U.S. research universities that graduated 2,520 engineering alumni in 2007. Of the 1,801 alumni for whom we had working email addresses in 2011, 543 completed the survey. We weighted this respondent sample by gender, major, and size of their engineering school to approximate the responses had all 2,520 graduates responded to the survey. The final PEARS sample was comprised of 484 survey respondents who completed the PEARS instrument, and the total weighted N was 2,249. For further details about the PEARS deployment see 2012 Chen[4].

Descriptive statistics as well as analyses of variance (ANOVAs) were conducted using the SPSS statistical software package.

Results

> ***(RQ1)*** *How might engineering alumni be characterized based on their levels of interest in and intention to pursue entrepreneurial activity?*

RQ1 focuses on understanding how levels of entrepreneurial interest and intention might be used to characterize engineering alumni. In the PEARS dataset entrepreneurial intention was measured by the question: *How likely is it that you will start a company or an organization in the near future?* as measured on a 5-point scale ranging from "Definitely Not" to "Definitely Yes." Entrepreneurial interest was operationalized by the item: *Are you interested in being an entrepreneur?* as measured on a 5-point scale ranging from "Not Interested" to "Extremely Interested." To help us understand how levels of entrepreneurial interest and intention might be used to characterize engineering alumni in the PEARS dataset, we classified alumni responses into one of four groups, or "quadrants" based on these two measures.

Table 1 illustrates how individual responses to each measure were assigned to either low or high levels of intention and interest.

For the measure, *How likely is that you will start a company or an* organization?, respondents who indicated that they were "probably not" or "definitely not" likely to start a company or an organization in the near future were classified as having low entrepreneurial intention. Those who responded "maybe," "probably yes, and "definitely yes" were classified as having high entrepreneurial intention.

For the measure, *Are you interested in being an entrepreneur?,* respondents who indicated that they were "Not Interested", "Slightly Interested", or "Moderately Interested" in being an entrepreneur were classified as having low entrepreneurial interest. Those who responded "Very Interested" or "Extremely Interested" were classified as having high entrepreneurial interest. In order to have representation across all four groups, we decided to assign the "Maybe" responses to the High Intention group, and the "Moderately Interested" responses to the Low Interest group. Subsequent analyses exploring how the inclusion of the "Maybe" respondents in the "Low Interest" group would affect the resulting four quadrants showed no significant differences

based on sex, school, major, and underrepresented minority status (URMs) for the resulting groups and slightly higher numbers of respondents for the Low Interest - High Intention and High Interest – Low Intention groups, thereby ensuring better representation across all four groups.

The resulting quadrants of entrepreneurial interest and intention are described as: 1) low interest – low intention; 2) low interest – high intention; 3) high interest – low intention; and 4) high interest – high intention.

Table 1. Classification of Alumni based on Responses to Intention and Interest Items

Question	**Response Option**	**Level of Intention/Interest Classification**
Q1: How likely is it that you will start a company or an organization in the near future?	Definitely Not	Low Intention
	Probably Not	Low Intention
	Maybe	High Intention
	Probably Yes	High Intention
	Definitely Yes	High Intention
Q2: Are you interested in being an entrepreneur?	Not Interested	Low Interest
	Slightly Interested	Low Interest
	Moderately Interested	Low Interest
	Very Interested	High Interest
	Extremely Interested	High Interest

* In order to have a well-represented four groups, the responses from "Maybe" were grouped under the High Intention group, and responses from "Moderately Interested" were grouped under the Low Interest group.

Table 2. Distribution of PEARS Respondents across the Interest-Intention Quadrants

High Interest - High Intention N = 104 22.20%	Low Interest - High Intention N = 49 10.50%
High Interest - Low Intention N = 65 13.80%	Low Interest - Low Intention N = 252 53.60%

Table 3 summarizes selected demographic characteristics of each of the four groups. In some ways the four groups are alike. For example, there were similar percentages of respondents who described their current and primary employed position to be an engineering position (69.0% to 79.9%) across all four quadrants. A little over 90 percent of the respondents in each group reported having parents who attended college for a bachelor's or associate's degree and approximately half of the respondents reported that their parents had advanced degrees. Most of the alumni across the four groups reported being U.S. citizens (85.1% to 94.2%).

Table 3 Summary of Demographic Characteristics of PEARS Respondents

Variable	Group 1 Low Interest Low Intention		Group 2 Low Interest High Intention		Group 3 High Interest Low Intention		Group 4 High Interest High Intention		Entire Dataset	
	N	%	N	%	N	%	N	%	N	%
Sex										
Female	68	26.80%	11	22.20%	8	13.10%	19	17.90%	113	23.30%
Male	185	73.20%	38	77.80%	56	86.90%	86	82.10%	372	76.70%
School										
School 1	55	21.70%	11	22.60%	13	19.60%	21	19.90%	101	20.90%
School 2	25	9.80%	9	18.00%	7	11.40%	25	23.70%	67	13.90%
School 3	57	22.50%	11	21.40%	18	27.80%	20	18.70%	111	22.90%
School 4	116	45.90%	19	37.90%	27	41.10%	39	37.80%	205	42.30%
Major										
Bioeng-Biomed Eng	8	3.30%	0	0.00%	3	4.50%	4	4.10%	16	3.20%
Chemical Eng	27	10.50%	2	4.00%	7	10.80%	12	11.10%	49	10.20%
Civil & Env. Eng	19	7.50%	5	10.00%	5	7.10%	6	6.20%	39	8.00%
Computer Sci & Eng	22	8.60%	1	2.00%	2	3.00%	9	8.90%	34	7.10%
Electrical Eng	34	13.60%	8	16.00%	7	10.20%	8	7.90%	61	12/50%
Industrial Eng	11	4.50%	3	6.00%	8	12.50%	11	10.30%	33	6.90%
Mechanical Eng	34	13.40%	8	16.00%	15	23.30%	13	12.20%	77	14.80%
Other Eng	97	38.60%	23	46.00%	19	28.70%	41	39.30%	188	37.30%
URM status (Sloan)										
Not URM	237	94.10%	45	91.20%	59	90.90%	84	80.70%	439	90.60%
URM	15	5.90%	4	8.80%	6	9.10%	20	19.30	45	9.40%
Family income status growing up										
Low Income	11	4.30%	2	4.70%	6	9.50%	4	3.60%	23	4.80%
Lower-middle income	43	17.00%	11	21.70%	8	12.30%	23	22.40%	85	17.70%
Middle income	111	44.10%	22	44.50%	21	33.00%	33	31.70%	192	39.70%
Upper-middle income	81	32.00%	13	25.50%	28	42.50%	34	32.60%	158	32.80%
High income	7	26.00%	2	3.60%	2	2.70%	10	9.80%	24	5.00%
Parents with bachelor's or associate's degree										
No	23	9.20%	3	6.50%	7	10.10%	13	12.50%	47	9.70%
Yes	228	90.80%	46	93.50%	58	89.90%	91	87.50%	435	90.30%
Parents with a an advanced degree										
No	119	47.50%	24	50.20%	28	43.70%	48	46.90%	226	47.50%
Yes	131	52.50%	24	49.80%	36	56.30%	54	53.10%	250	52.50%
Citizenship Status										
A U.S. Citizen	238	94.20%	42	86.00%	60	92.90%	89	85.10%	437	90.50%
Permanent resident	4	1.50%	2	4.40%	5	0.00%	3	2.50%	9	1.80%
Other	11	4.30%	5	9.70%	65	7.10%	13	12.40%	38	7.80%
Current position										
An Engineering position	201	79.90%	34	70.90%	49	75.70%	70	69.00%	354	75.96%
A non-engineering position	50	20.10%	14	29.10%	16	24.30%	32	31.00%	112	24.03%
Women URM (Sloan)										
No	61	90.70%	10	92.80%	8	100.00%	16	84.30%	35	78.00%
Yes	6	9.30%	1	7.20%	0	0.00%	3	15.70%	10	22.00%

Additionally, table 3 illustrates the major differences were between the low interest – low intention group, and the other three groups, or between the high interest – high intention group and the other three groups. For instance, there was a higher percentage of underrepresented minority respondents in the high intention - high interest group (19.3%) as compared to the other three groups (ranging from 5.9% to 9.1%). Similarly, 9.8 percent of the respondents who reported a family income status of high income while growing up were present in the high intention - high interest group while this representation ranged from 2.6 percent to 3.6 percent in the other three groups.

The following includes some additional results characterizing each group:

Low Interest - Low Intention Group: 53.8 percent (n=254) of the alumni respondents were represented in this group. This group had the highest percentage of females (26.8%) and the lowest percentage of URM respondents (5.9%), as compared to the other three groups. The Low Interest – Low Intention group had the lowest percentage of PEARS respondents who reported having a high family income while growing up (2.6%). This percentage is similar to the Low Interest- High Intention group (3.6%) and the High Interest – Low Intention group (2.7%), but it is very low compared to the High Interest – High Intention group (9.8%).

Low Interest - High Intention Group: 10.6 percent (n=50) of the alumni comprised this group, and 22.2 percent were females. Also, 8.8 percent of the alumni from this group were URM.

High Interest – Low Intention Group: 13.6 percent (n=64) of the alumni comprised this group, and 13.1 percent were females. While 9.1 percent of the alumni were URMs, this was the only group that did not have any URM women.

High Interest – High Intention Group: 22.0 percent (n=104) of the alumni comprised this group. Despite having the lowest percentage of females (17.9%), this group had the highest percentage of alumni respondents with URM status (19.3%) as well as the highest percentage of URM women (15.7%). As mentioned above, this group had both the highest percentage of alumni who reported having a high family income (9.8%) and the lowest percentage of alumni (3.6%) who reported having a low family income while growing up.

Even though most of the alumni across the groups were U.S. citizens, the High Interest - High Intention group had the highest percentage of alumni who identified with "Other" with respect to their citizenship status (12.4%). Finally, while the percentage of alumni reporting that they were currently in an engineering position was largely similar across the groups, it was the lowest among this group (69.0%); the other groups ranged from 70.9 to 79.9 percent.

> *(**RQ2**) What similarities and differences in desired career outcomes, career satisfaction, and undergraduate learning experiences exist among engineering alumni with varying levels of entrepreneurial interest and intention?*

Desired Career Outcomes and Career Satisfaction

In a study of 111 men and women entrepreneurs, Parasuraman, Purohit, Godshalk and Beutell[16] identified career satisfaction as one indicator of entrepreneurial success and well-being.

Additional factors related to increased job satisfaction include self-reported progress towards income goals, the development of new skills as well as seeking a position that enables autonomy and the perception of greater control and flexibility to address the balance of work-life responsibilities[16].

To better understand the similarities and differences among the quadrants of entrepreneurial interest and intention, we draw upon the work of Duval, Reed, Haghighi[9] who investigated the role of engineering programs and the career plans of engineering students. In their study of 343 engineering students enrolled in senior-level capstone design courses at three different large public universities with established entrepreneurship programs, students were asked why they would and would not start a business as a way to understand future career choices in entrepreneurship. The top ranked reasons for starting a business were to "satisfy a need in the market," "have more flexibility and independence," "focus on a technology that interests me," and "create something of my own." The top ranked reasons for not starting a business were: a "lack of initial capital for startup," "lack of legal assistance or counseling," "excessively risky," and a "lack of ideas of what business to start." Some of these reasons were used to identify the similarities and differences among the four quadrants.

In the PEARS dataset, we measure career satisfaction through the item, *How satisfied are you with the success you have achieved in your career so far?* as measured on a 5-point scale ranging from *Very Dissatisfied* to *Very Satisfied*.

The importance of autonomy, the development of new skills, and career advancement as factors influencing career decisions are operationalized using the PEARS items described below and were measured on a 5-point scale ranging from *Not important* to *Extremely important*.

How important has each of the following been to you in your career-decision-making so far?

Autonomy

- Having a job that gives me time for family, friends, and hobbies
- Having a job with a high level of independence and self-direction
- Doing work that helps me figure out what I am really interested in

Development of new skills

- Desire for additional education and training

Career Advancement

- Finding a job that is a stepping stone to other opportunities
- Having a job that puts me on the "fast track" for career advancement

One-way ANOVAs and post-hoc analyses were conducted to examine the means by group. Table 4 highlights where the mean differences were statistically significant. The numbers at the top of the range of scores are indicated in bold, and the numbers at the bottom of the range are underlined.

Table 4. Desired Career Outcomes according to Interest-Intention Quadrants

Variable	**Group 1 Low Interest- Low Intention N=254**		**Group 2 Low Interest- High Intention N=64**		**Group 3 High Interest- Low Intention N=50**		**Group 4 High Interest- High Intention N=103**		**Overall ANOVA F-statistic**
	M	**SD**	**M**	**SD**	**M**	**SD**	**M**	**SD**	
Career Satisfaction	**2.86**	.95	2.74	1.02	2.65	1.18	2.51	1.01	3.189* Gr. 1>Gr. 4
Time for family and friends	2.80	.93	2.58	1.04	2.59	1.08	2.71	1.06	1.246
Job with independence and self-direction	2.48	.89	2.30	1.06	2.80	.98	**2.93**	.88	8.788 *** Gr. 4>Gr. 1 Gr. 4>Gr. 2
Doing work that helps me figure out what I am interested in	2.27	.90	2.44	.73	2.18	.94	**2.55**	.99	3.190* Gr. 4>Gr. 1
Additional education and training	2.07	1.10	2.25	1.09	2.07	1.18	**2.50**	1.18	3.757** Gr. 4>Gr.1
'Fast track' for career advancement	1.71	1.13	2.08	1.24	**2.27**	1.12	**2.25**	1.15	7.758*** Gr. 3>Gr. 1 Gr. 4>Gr. 1
A job that is a stepping stone to other opportunities	2.55	.98	2.83	.88	**2.95**	.98	**2.88**	.95	5.112*** Gr. 3>Gr. 1 Gr. 4>Gr. 1

* $p<0.05$, ** $p<0.01$, *** $p<0.001$

For *career satisfaction*, there was a statistically significant difference between groups as determined by one-way ANOVA ($F(3,463) = 4.467$, $p = 0.024$). A Tukey post-hoc test revealed that the Low Interest – Low Intention group (2.86 ± .95, $p = 0.016$) was significantly higher than the High Interest - High Intention group (2.51 ± 1.01). There were no statistically significant differences among the other groups.

For *a job with independence and self-direction*, there was a statistically significant difference among the four as determined by an one-way ANOVA ($F(3,465) = 8.788$, $p = 0.000$). A Tukey post-hoc test revealed that the High Interest – High Intention group (2.93 ± .88, $p = 0.000$) was significantly higher than the Low Interest – Low Intention group (2.48 ± .88). Also, the test revealed that the High Interest – High Intention group (2.93 ± .88, $p = 0.000$) was statistically significantly higher than the Low Interest – High Intention group (2.30 ± 1.06).

There was a significant difference among the four groups for the variable related to the importance of *doing work that helps me figure out what I am interested in* ($F(3,464) = 3.190$, $p = 0.024$). A Tukey post-hoc test revealed that the High Interest – High Intention group (2.55 ± .99, $p = 0.041$) was significantly higher than the Low Interest – Low Intention group (2.27± .89).

For the variable related to the *importance of additional education and training* in career decision-making, there was a significant difference among the groups ($F(3,465) = 3.757$, $p = 0.011$). A Tukey post-hoc test revealed that the High Interest – High Intention (2.50 ± 1.18, $p = 0.007$) group was significantly higher than the Low Interest – Low Intention group (2.07 ± 1.10). There were no significant differences among the other groups.

For the variable, *'fast track' for career advancement*, there was a statistically significant difference among groups as determined by one-way ANOVA ($F(3,461) = 7.758$, $p = 0.000$). A Tukey post-hoc test revealed that the High Interest – High Intention (2.25 ± 1.15, $p = 0.000$) group was significantly higher than the Low Interest – Low Intention group (1.71 ± 1.13). The also test revealed that the High Interest – Low Intention group (2.27 ± 1.12, $p = 0.004$) was significantly higher than the Low Interest – Low Intention group (1.71 ± 1.13).

A significant difference among the groups was seen with the variable, *a job that is a stepping stone to other opportunities*, ($F(3,465) = 4.768$, $p = 0.002$). A Tukey post-hoc test revealed that the High Interest – High Intention group (2.88 ± .95, $p = 0.016$) was significantly higher than the Low Interest – Low Intention group (2.55 ± .981). Also, the test revealed that the High Interest – Low Intention group (2.95 ± .98 min, $p = 0.015$) was significantly higher than the Low Interest – Low Intention group (2.55 ± .981).

Influences of Undergraduate Career Interests and Learning Experiences

In a study of 27,783 Stanford alumni, Eesley and Miller[9] describe Stanford's role in fostering entrepreneurship in undergraduate students through the creation of and exposure to different entrepreneurial activities and environments. The Stanford Innovation Survey is a systematic survey of Stanford alumni, faculty and selected staff that assesses the university's economic impact based on involvement in entrepreneurship. The study outlines some of the different learning experiences that alumni encountered as undergraduates, which may have influenced their perception of entrepreneurship. Approximately one-third of the alumni respondents reported being entrepreneurs who founded an organization, and described themselves as investors, early employees or board members in a startup at some point in their careers. Eesley and Miller[9] found that as undergraduates, successful entrepreneurs and technology innovators were more likely to have worked with faculty (67.9%), taken an entrepreneurship course (18.9%), participated in research (57.6%), been part of a student group (62.9%), studied abroad (20.7%), and accessed an alumni network for advising or mentoring (37.7%).

In the PEARS dataset, we measured undergraduate exposure to various learning experiences by asking respondents to indicate which of the following activities they had engaged with as undergraduates:

a. While an undergraduate engineering student, did you do each of the following for at least one full academic or summer term?

- Conduct engineering research with a faculty member

b. While an undergraduate, did you: (Mark all that apply.)

- Participate in a study abroad program
- Participate in engineering-related student clubs, groups, or community service (e.g., Engineers Without Borders)
- Participate in student clubs, groups, or community service outside of engineering

Table 5. Participation in Undergraduate Learning Experiences across Interest-Intention Quadrants

Variable	Group 1 Low Interest Low Intention		Group 2 Low Interest High Intention		Group 3 High Interest Low Intention		Group 4 High Interest High Intention		Entire Dataset	
	N	%	N	%	N	%	N	%	N	%
Conduct Research										
No	176	69.90%	33	66.70%	36	55.10%	66	62.90%	311	66.02%
Yes	76	30.10%	16	33.30%	29	44.90%	39	37.10%	160	33.97%
Participate in clubs, groups, community engineering related										
No	115	45.90%	23	45.60%	35	54.40%	42	40.60%	215	45.74%
Yes	136	54.10%	27	54.40%	30	45.60%	62	59.40%	255	54.25%
Participate in clubs, groups, community outside engineering										***
No	62	28.80%	4	7.30%	22	34.70%	19	18.50%	107	27.45%
Yes	189	75.20%	46	92.70%	42	65.30%	85	81.50%	362	72.54%
Participate in a study abroad program										**
No	233	92.20%	41	83.90%	60	93.10%	86	82.10%	420	89.17%
Yes	20	7.80%	8	16.10%	4	6.90%	19	17.90%	51	21.31%

*** $p<0.001$, ** $p<0.01$. * $p<0.05$

The summary of results in Table 5 reinforce the findings from the Eesley and Miller[9] study. Pearson's chi-square test was conducted to assess whether varying levels of entrepreneurial interest and intention was associated with participation in undergraduate learning experiences. Alumni respondents in the High Interest - High Intention and the Low Interest – Low Intention group reported fairly comparable participation in student clubs, groups, or community service outside of engineering ($p<0.001$). This was also true for study abroad programs ($p<0.01$), where both the Low Interest – Low Intention and the High Intention – High Interest groups also reported fairly comparable participation levels.

Winters, Matusovich, and Carrico[20] found that faculty play a very important role in influencing and helping students prepare for specific career paths. In our study we were interested in how the degree of student-faculty engagement during the undergraduate years varied among the four different entrepreneurship interest-intention groups.

In the PEARS dataset, we operationalized frequency of undergraduate interactions with professors as follows. Each of these items was measured on a 5-point scale ranging from *Never* to *Very Often.*

While an undergraduate engineering student, how often did you discuss each of the following with your engineering professors:

- Course material and assignments outside of class
- Your professional options with an engineering degree
- How skills you learned in class apply to "real-life" engineering practices

Table 6. Frequencies of Topics Discussed by Undergraduate Engineering Students and Engineering Professors

Variable	Group 1 Low Interest Low Intention		Group 2 Low Interest High Intention		Group 3 High Interest Low Intention		Group 4 High Interest High Intention		Overall ANOVA F-statistic
	M	**SD**	**M**	**SD**	**M**	**SD**	**M**	**SD**	
Course material and assignments outside class	1.85	0.96	2.04	0.69	**2.09**	1.00	<u>1.71</u>	1.05	2.77 * Gr. 3>Gr. 4
Professional options with engineering degree	1.20	0.89	1.27	0.82	1.46	1.07	1.28	1.04	1.34
How skills learned applied to real-life engineering	1.43	0.93	1.57	0.93	1.75	1.14	1.67	1.17	2.37

* p<0.05, ** p<0.01, *** p<0.001

One-way ANOVAs were used to examine the means by interest-intention. Using post hoc comparisons were conducted to identify which pairs of means were significantly different. Table 6 highlights where were differences statistically significant with the numbers at the top of the range of scores indicated in bold, and numbers at the bottom of the range are underlined.

For the topic, discussing *course material and assignments outside class*, there was a statistically significant difference among the groups ($F(3,466) = 2.768$, $p = 0.041$). A Tukey post-hoc test revealed that the High Interest – Low Intention group (2.09 ± 1.00, $p = 0.05$) was statistically significantly higher than the High Interest - High Intention group (1.71 ± 1.05). There were no statistically significant differences among the other groups.

Although not significant, the High Interest – Low Intention group reported higher frequency of discussing with faculty the *professional options associated with an engineering degree* as compared to the other three groups. In comparison to the other three groups, alumni in the High Interest – Low Intention group were more likely report talking about *how skills learned in class applied to real-life engineering practice* with their professors during their undergraduate years.

Discussion

In this study, engineering alumni were categorized based on two measures of their entrepreneurial interest and intention and divided into four groups: Low Interest – Low Intention, High Interest – Low Intention, Low Interest – High Intention, and High Interest – High Intention. Prior research conducted with alumni and other populations have largely focused on either

entrepreneurial interest or entrepreneurial intention, but this study attempts to explore the varying levels of interactions between these two variables and draw meaningful parallels.

The four interest-intention groups were described in terms of their demographic characteristics, desired career outcomes and career satisfaction, and their undergraduate learning experiences. With regards to the levels of entrepreneurial interest and intention possessed by engineering alumni, underrepresented minorities were more prevalent in the High Interest – High Intention group as compared to the other three groups. Promising opportunities for engaging URM students and alumni are being explored through initiatives such as the 2014 inaugural cohort of the Historically Black Colleges and Universities (HBCU) Innovation and Entrepreneurship Collaborative (IEC), sponsored by the Association of Public and Land-grant Universities (APLU) Office for Access and Success, National Collegiate Inventors and Innovators Alliance (NCIIA), the United State Patent and Trademark Office and the United Negro College Fund (UNCF). The purpose of this multi-year collaboration is to convene a cohort of 15 HBCUs (both public and private) around fostering innovation, commercialization and entrepreneurship on their respective campuses.

Alumni who reported having a high family income were more likely to be in the High Interest – High Intention group while alumni who reported having a low family income were most likely to be in the Low Intention – Low Interest group. This finding might suggest that family income while growing up may be associated with the likelihood engineering alumni expressing interest in pursuing entrepreneurial activity in the future.

The highest percentage of females was found in the Low Interest – Low Intention group; however, the noticeable lack of a female presence across the four groups is consistent with the low representation of women students in engineering in general. While the majority of engineering alumni across the four groups reported being U.S. citizens, the highest percentage of alumni whom identified as having "other" citizenship status was found in the High Interest-High Intention group, suggesting that entrepreneurially minded alumni are not limited by their citizenship status and perhaps may be more motivated to pursue entrepreneurial ventures. Across the four groups, the majority of engineering alumni were similar, since the majority reported that their current and primary positions were in engineering fields.

Two desired career outcomes were shared among entrepreneurially-minded alumni: They were more likely to seek jobs that afforded them independence and self-direction and that would put them on the 'fast track' towards career advancement.

In regards to undergraduate experiences, over a third of engineering alumni in all groups reported conducting research with a faculty member. Approximately half of the alumni in all groups reported participating in student clubs, groups or community services inside engineering (ranging from 45.6% to 59.4%). However, the proportion of alumni who reported participating in student clubs, groups or community services outside of engineering as undergraduates is significantly influenced by varying levels of entrepreneurial interest and intention. We also observed a higher representation of alumni who participated in study abroad programs in the High Interest – High Intention group as compared with the other alumni in the other three groups. Given, that these kinds of undergraduate experiences are also considered to be "high

impact practices" that are correlated with student persistence and retention. Further work exploring the relationship between high impact practice, student engagement, and the development of an entrepreneurial mindset as part of a liberal education would be especially fruitful.

We hope that the interest-intention quadrants will be a useful framework to inform a more comprehensive understanding of the characteristics engineering alumni and their entrepreneurial activity. Armed with this deeper knowledge, engineering education researchers will then be able identify specific patterns in behavior and the kinds of undergraduate experiences that might contribute to engineering students' entrepreneurial direction after graduation and support their successful transition from the academic setting into highly innovative work environments.

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