



Exploring the Interest and Intention of Entrepreneurship in Engineering Alumni

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Abstract

America's economic growth and international competitiveness significantly depend on its ability to innovate⁹. Entrepreneurship is an important pathway to innovation and leadership—however, until recently there has been little research exploring what factors influence whether or not engineering graduates will engage in entrepreneurial activities.

This study explored how engineering alumni who are interested in starting a business or an organization may be similar to or different from their peers based on a number of measures. We also explored why some engineering alumni who co-founded or started a company in the past may no longer have an entrepreneurial interest. A logistic regression was conducted to explore what variables were the most important in predicting a student's intention and interest in pursuing entrepreneurial activities.

Three research questions guided this study:

1. How do engineering alumni with high intentions and high interest in pursuing entrepreneurial activities compare with peers with low entrepreneurial intention and interest in terms of demographics, career-related characteristics, self-confidence and interest in technical concepts and problems?
2. What factors influence alumni's interest in and intention to pursue entrepreneurial activities?
3. For engineering alumni who have been entrepreneurs in the past, what activities led them to either become more entrepreneurially-minded or divert to a non-entrepreneurial career path?

The participants in this study were 484 alumni who received their undergraduate engineering degrees in 2007 from four different universities in the United States. Our research aims to help engineering educators understand the factors that promote and contribute to entrepreneurial pursuits among engineering alumni. In addition, by identifying what factors or circumstances influence entrepreneurial activities, engineering schools may design programs and identify potential opportunities for intervention.

1. Background

In an environment of growing market competitiveness and business pressures¹, there is a critical need for engineers with entrepreneurial knowledge and skills. However, the traditional engineering curriculum often does not expose students to entrepreneurial education. Students with entrepreneurial training can contribute valuable skills to the workplace; for example, managing interdisciplinary teams, communicating effectively, thinking critically, understanding business basics, and solving open-ended problems.¹

Entrepreneurship is a way of thinking where individuals identify opportunities to innovate. Following through on those opportunities is an intentional act. Thus, strong intentions to start a business are likely to result in efforts toward acting upon those intentions.³ In this study we

investigated to what degree entrepreneurial intentions held by engineering alumni result in actual entrepreneurial activity. Intentions are a critical predictor of any planned behavior, including entrepreneurship⁶. Intentions can explain and predict how alumni see opportunities that may lead to business ideas that may eventually be brought to market. Entrepreneurial intention, in combination with both situational and individual variables, possibly can explain and predict entrepreneurial patterns among engineering alumni. In the current study, intentions were used to identify which characteristics of engineering alumni might predict future entrepreneurial action.

With respect to entrepreneurial interest, Lent, Brown, Sheu, Schmidt, and Brenner 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.¹⁰ We propose that alumni who have shown high interest are more likely to pursue entrepreneurship, since interest will result in a higher likelihood of entrepreneurial action.

We hypothesized that alumni who have expressed high intentions to pursue entrepreneurial activities are more likely to seek out these activities. This included constructing a model to identify which are the important factors that predict whether engineering students will pursue entrepreneurial activities. Lastly, we explored what factors influenced alumni who had been entrepreneurs in the past to divert to a non-entrepreneurial career path.

The work of Duval-Couetil, Reed-Rhoads and Haghighi is relevant to the current study. In their study of 501 engineering students enrolled in senior-level capstone design courses at three institutions with established entrepreneurship programs, they explored the attitudes and outcomes of entrepreneurship education on engineering students, as well as entrepreneurship's role in their career plans, and its impact on entrepreneurial self-efficacy.⁵ The authors found that students' reasons for starting a business were to "satisfy a need in the market," "focus on a technology that interests me," "create something of my own," "have more flexibility and independence," "solve a social problem," "be at the head of an organization," "manage people," "make more money," "create jobs," "have more free time," "gain high social status," and "following a family tradition."

In addition, Duval-Couetil, Reed and Haghighi explored the attitudes and outcomes of entrepreneurship education on engineering students, as well as entrepreneurship's role in their career plans and its impact on entrepreneurial self-efficacy.⁶ In this study, some of the reasons the authors found for students deciding not to start a business were due to the "current economic situation," "lack of legal assistance or counseling," "lack of experience in management and finance," "lack of ideas regarding what business to start," "lack of knowledge of the business world and the market," "irregular income", "having to work too many hours," "doubts about personal abilities." Many of these reasons are also considered in the current study to identify what activities led entrepreneurs to continue or not continue in an entrepreneurial pathway.

The current research is an extension of an earlier study in which we identified factors associated with entrepreneurial interest and entrepreneurial intention among engineering alumni¹⁴. We build on the framework presented in that earlier study, where it was found that desired career outcomes and career satisfaction, as well as the influence of undergraduate career interest and

learning experiences, were main areas that characterize engineering alumni with high interest and high intentions to engage in entrepreneurship.

As compared to our earlier study, in the current research a wider range of characteristics related to entrepreneurial intention and interest are considered. In addition to considering what might distinguish repeated engagement in entrepreneurial activities. We attempt to understand why entrepreneurially-minded alumni divert from entrepreneurship by building a model to predict which characteristics are associated with entrepreneurially-minded students. While several studies have identified factors that are associated with either entrepreneurial interest or entrepreneurial intention among alumni, there is little research that analyzes both of these factors simultaneously.

It is critical that universities provide their students with opportunities for entrepreneurship training in order to supply the workforce with professionals who are innovative team members and managers. This requires university faculty and staff to understand what kinds of undergraduate experiences are associated with fostering highly innovative alumni. Recently graduate students' early interest in and intentions in exploring entrepreneurship can provide some insights into these experiences. To extend our understanding of what leads students to take an entrepreneurial path, we undertook analyses guided by the following three research questions:

1. How do engineering alumni with high intentions and high interest in pursuing entrepreneurial activities compare with peers with low entrepreneurial intention and interest in terms of demographics, career-related characteristics, self-confidence and interest in technical concepts and problems?
2. What factors influence alumni's interest in and intention to pursue entrepreneurial activities?
3. For engineering alumni who have been entrepreneurs in the past, what activities led them to either become more entrepreneurially-minded or divert to a non-entrepreneurial career path?

2. 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. Deployed to 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^{2,5,8}.

The objectives of the PEARS research 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 overcoming challenges⁵.

Table 1 shows that women represented 23.4 percent of the engineering alumni surveyed, and 6.2 percent of the sample were self-identified as underrepresented minorities (URM). Some 39.7 percent of the respondents indicated that their family income while growing up was in the middle-income range and 32.8 percent reported being in the upper-middle income range. The majority of engineering alumni indicated they were currently working in an engineering position (72.6%) and only a small fraction of engineering alumni had co-founded or started a company (7.8%).

Table 1. Demographics of the Sample of Engineering Alumni Surveyed

Variable	N	%
Sex		
Female	113	23.4%
Male	371	76.6%
Total	484	100.0%
Race		
URM	29	6.2%
Non-URM	430	93.8%
Total	459	100.0%
Family income growing up		
Low income	24	4.8%
Low-middle income	85	17.7%
Middle income	192	39.7%
Upper-middle income	158	32.8%
High income	24	5.0%
Total	483	100.0%
Current position		
An engineering position	366	76.2%
A non-engineering position	114	23.8%
Total	480	100.0%
Major		
Aeronautical & Astronautical	34	6.5%
Chemical	49	10.2%
Civil	38	7.8%
Computer	20	4.2%
Electrical	61	12.6%
Engineering	56	11.6%
Industrial	33	7.0%
Mechanical	72	14.9%
Petroleum	12	2.4%
Other Engineering	109	22.8%
Total	484	100.0%
Co-founded or started a company		
Co-founded a company	38	7.8%
Did not co-found a company	447	92.2%
Total	485	100.0%

3. Methodology

The PEARS instrument was administered online to engineering graduates four years after they earned 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 the research team had working email addresses for in 2011, 543 completed the survey. This respondent sample was weighted by gender, major, and size of alumni engineering school to approximate the responses had all 2,520 graduates responded to the survey. The final PEARS sample was composed of 484 survey respondents who completed the PEARS instrument, and the total weighted N was 2,249.⁴

We focused on characterizing alumni according to their entrepreneurial intentions, entrepreneurial interest, and related factors. To compare means on Likert-scale measures, we performed paired sample t-tests and report p-values as well as Cohen's d as an indicator of effect size. Cohen's d calculations help compensate for the dependence of p-values on sample size. That is, when the sample size is very large, nearly all differences, even meaningless differences, can have very small p-values (e.g., <.05). In contrast, the effect size, Cohen's d, is a measure of the greatness of difference and is independent from sample size. Thus, both Cohen's d and p-values were calculated in each of the comparisons to allow us to better interpret differences between groups. For reporting purposes, we focus on differences classified as "small" or "medium" or "large", using Cohen's d guidelines: small d = 0.2 - 0.5, medium d = 0.5 - 0.8, and large d \geq 0.8⁴

Based on the results, nonparametric Mann–Whitney U post-hoc tests were used to examine the statistical differences between groups. All assumptions of these nonparametric tests were met in the analyses. The survey items used Likert-type, 5-point scales. The level of statistical significance was set at a p-value less than .05.

4. Results

In order to understand what might be driving some recent graduates towards an interest in entrepreneurship or even an intention to start something entrepreneurial, we consider several sub-groupings of the population described in Table 1. These sub-groups compared alumni with high intention and low intention. A similar process was used to characterize alumni with high and low interests in entrepreneurship. Later on, based on the individual findings from the high interest and high intention groups, a new group was defined: the high interest – high intention group. This group was used to build a model to predict which factors influence alumni's pursuit of entrepreneurial activities.

4.1 Factors Connected to Entrepreneurial Intention and Interest

(RQ1) How do engineering alumni with high intention and high interest in pursuing entrepreneurial activities compare with peers with low entrepreneurial intention and interest in terms of demographics, career-related characteristics, self-confidence and interest in technical concepts and problems?

One part of RQ1 focuses on understanding the characteristics of engineering alumni who express high intention to pursue entrepreneurial activities as compared with their peers with low intentions. The other part of RQ1 focuses on understanding how alumni with high interest in entrepreneurial activities compare with their peers with low interest. For this study two **INTENTION** groups were formed based on participants' answers to the question: *How likely is it that you will start a company or an organization in the near future?* This question was measured on a 5-point scale ranging from "Definitely Not" to "Definitely Yes." Respondents who indicated that they were "Definitely Not" or "Probably Not" likely to start a company or an organization in the near future were classified as having low entrepreneurial intention, whereas those who responded "Maybe," "Probably Yes," and "Definitely Yes" were classified as having high entrepreneurial intention.

The other part of RQ1 is focused on understanding interest in entrepreneurship. Two **INTEREST** groups were formed based on participants' answers to the question: *Are you interested in being an entrepreneur?* Respondents who indicated that they were "Not Interested" or "Slightly" interested in being an entrepreneur were classified as having low entrepreneurial interest. Those who responded "Very Interested," "Extremely Interested," or "Moderately Interested" were classified as having high entrepreneurial interest.

Table 2 illustrates how individual responses to these questions and options were assigned to determining the two INTENTION groups and the two INTEREST groups.

Table 2. Mapping of Intention and Interest Responses to High/Low Intention and Interest Groups

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

4.1.1 Characterization of Engineering Alumni According to Entrepreneurial Intention and Interest

Table 3 summarizes selected demographic characteristics for the High and Low Entrepreneurial Intention Groups (in columns a and b), and the High and Low Entrepreneurial Interest Groups (in columns c and d).

INTENTION: Women make up 19.4 percent of the high intention group, slightly less than their 23.4 percent representation of the sample as a whole (see Table 1). The high intention group had a higher percentage (12.9%) of self-identified under-represented minority alumni, as compared to the low intention group (3.3%). The percentages reported for family income growing up were similar across the high and low intention groups. Fewer engineering alumni in the high intention group (69.8%) indicated they were currently in an engineering position as compared to the low intention group (79.1%). The total number of engineering alumni who had co-founded or started a company made up 19.2 percent of the high intention group; this represents 7 of the 38 alumni who had co-founded or started a company.

INTEREST: Women represented 23.4 percent of the engineering alumni surveyed, and 29.6 percent of the high interest group. The high interest group also had a higher representation of URM alumni (8.5%), as compared to the low interest group (3.4%). About three-quarters of the respondents in both the high interest (73.6%) and low interest (79.7%) groups reported currently holding an engineering position. Of the 38 engineering alumni who reported co-founding or starting a company, 35 were in the high entrepreneurial interest group.

In addition to these demographic characteristics, we examined several variables focusing on career interests and confidence in skills related to the professional work-setting in order to further understand the similarities and differences between the high and low intention groups.

4.1.2 Career-Related Characteristics and High-Low Intention and Interest Groups

In the PEARS dataset, factors related to participants' career paths were measured through the nine items about the importance to one's career-decision making so far, *How important has each of the following been to you in your career-decision-making so far?* on a 5-point scale ranging from *Not Important* to *Extremely Important*.

Career Advancement

- Having a well-paying job
- Having a secure job
- Finding a job that is a stepping stone to other opportunities

Social Good

- Doing work that allows me to contribute to fixing problems in the world
- Having a job that allows me to contribute to the good of society

Job Characteristics

- Having a job that is intellectually interesting
- Having a job with a high level of independence and self-direction

Family Considerations

- Having a job that would please my family
- Having a job that gives me time for family, friends and hobbies

Table 3. Demographics of the High and Low Intention Groups, and High and Low Interest Groups.

Variable	INTENTION				INTEREST			
	(a) High Intention		(b) Low Intention		(c) High Interest		(d) Low Interest	
	N	%	N	%	N	%	N	%
	155	32.8	317	67.2	282	59.9	193	40.1
Sex								
Female	30	19.4%	76	24.0%	50	17.8%	57	29.6%
Male	125	80.6%	241	76.0%	232	82.2%	136	70.4%
Total	155	100.0%	317	100.0%	282	100.0%	193	100.0%
Race								
URM	19	12.9%	10	3.3%	22	8.5%	6	3.4%
Non-URM	126	87.1%	293	96.7%	242	91.5%	181	96.6%
Total	145	100.0%	303	100.0%	264	100.0%	187	100.0%
Family income growing up								
Low income	6	3.9%	17	5.3 %	16	5.7%	7	3.6%
Low-middle income	34	22.0%	51	16.0%	55	19.4%	31	15.9%
Middle income	56	36.3%	133	41.8%	106	37.5%	83	42.9%
Upper-middle income	47	30.1%	108	34.2%	89	31.6%	68	35.6%
High income	12	7.7%	8	2.7%	16	5.8%	4	2.0%
Total	155	100.0%	317	100.0%	282	100.0%	193	100.0%
Current position								
An engineering position	106	69.8%	250	79.1%	205	73.6%	153	79.7%
A non-engineering position	45	30.2%	66	20.9%	74	26.4%	39	20.3%
Total	151	100.0%	316	100.0%	279	100.0%	192	100.0%
Major								
Aeronautical & Astronautical	6	3.6%	25	8.0%	16	5.5%	15	7.9%
Chemical	12	8.0%	34	10.7%	23	8.2%	25	13.0%
Civil	11	7.2%	23	7.3%	22	7.9%	12	6.1%
Computer	6	3.8%	15	4.6%	8	2.8%	13	6.6%
Electrical	18	11.7%	41	13.0%	35	12.4%	25	13.0%
Engineering	28	17.9%	27	8.7%	37	13.3%	18	9.7%
Industrial	14	9.1%	20	6.2%	25	9%	8	4.3%
Mechanical	21	13.9%	49	15.6%	43	15.2%	28	14.7%
Petroleum	3	2.2%	8	2.4%	8	2.5%	3	1.8%
Other Engineering	35	22.3%	80	26.2%	64	23.0%	51	27.2%
Total	154	100.0%	314	100.0%	281	100.0%	190	100.0%
Co-founded or started a company								
Co-founded a company	30	19.2%	7	2.3%	35	12.4%	3	1.3%
Did not co-found a company	125	80.8%	310	97.7%	247	87.6%	191	98.7%
Total	155	100.0%	317	100.0%	282	100.0%	194	100.0%

The high and low intention groups, and the high and low interest groups were then compared on these items using paired-sample *t* tests. Table 4 summarizes these comparisons for the high/low intention groups (columns (a) and (b)) and the high/low interest groups (columns (c) and (d)). Statistically significant mean differences are shown in bold.

INTENTION: Of this list of career-related characteristics, two of the career-advancement items were significantly different between the high and low intention groups. For the low intention group having a secure job was more important, whereas for the high intention group having a job that was a stepping stone to other opportunities was more important. Having a well-paying job was of comparable importance for both groups. There were similar means for both groups for the social good and family considerations items. Both groups were also comparable on desiring a job that is intellectually interesting, but those in the high intention group ascribed greater importance to having a job with a high level of independence and self-direction.

INTEREST: We found similar trends between the high and low interest groups as we did with the high and low intention groups. Having a job that is intellectually interesting was significantly more important to the high interest group than the low interest group at $p < .001$. Having a well-paying job was also significantly more important for the high interest group as compared with the low interest group (the difference was not significant between the high and low intention groups). Also, the high interest group placed a higher importance on doing work that contributed to fixing problems in the world than the low interest group ($p < .05$).

4.1.3 Confidence in Professional Work Setting Skills, and Engagement with Technical Concepts and Problems

We also consider how the high-low intention groups and high-low interest groups might compare on professional skills and technical engagement. Our consideration of professional skills was motivated by a study of 4,192 of Informational Technology professionals, where individuals' intent to pursue an entrepreneurial career was influenced by the work environment and personal factors. Intentions to start a business may be boosted by the level of confidence on personal factors, such as leadership and relationships among colleagues.¹¹ In this paper, self-confidence in the application of skills in a professional-work setting was measured through using the following item: *How confident are you in applying the following skills in a professional – work setting at this time?* The responses were measured on a 5-point scale ranging from *Not Confident* to *Extremely Confident*.

Technical skills may also influence interest in entrepreneurial activities. Here we wanted to see if strong technical interests were related to strong entrepreneurial interests. Some of the selected variables that contributed to interest in entrepreneurship represented occasions in which students might have been introduced to entrepreneurship either in an engineering-related project or during an engineering course. Two items were used to measure interest in intention: working on a project involving engineering or scientific concepts and solving complicated technical problems. Responses were measured on a 5-point scale ranging from *Not Interested* to *Extremely Interested*. For both of these variables, a paired-sample *t* test was conducted to evaluate whether the means were significantly different between the high and low intention groups. Table 5 highlights where the mean differences were statistically significant and are indicated in bold.

Table 4. Means and Standard Deviations of Career-Related Characteristics for the High and Low Intention, and High and Low Interest Entrepreneurial Groups

Importance of Career-Related Characteristics	INTENTION								INTEREST					
	(a) High Intention		(b) Low Intention		p-value ¹	t	d ²	(c) High Interest		(d) Low Interest		p-value ¹	t	d ²
	Mean	SD	Mean	SD				Mean	SD	Mean	SD			
Career Advancement														
A well-paying job	2.63	0.97	2.61	0.89	.77	-0.28	0.02	2.69	0.92	2.51	0.92	<.05*	-2.10	0.19
A secure job	2.50	1.08	2.89	0.85	<.001***	4.32	0.40	2.65	0.99	2.90	0.88	<.001***	2.80	0.27
Stepping stone to opportunities	2.87	0.93	2.63	0.99	<.001***	-2.25	0.25	2.87	0.95	2.44	0.97	<.001***	-4.77	0.44
Social Good														
Fixing problems in the world	2.48	1.19	2.38	1.08	.33	-0.96	-0.32	2.52	1.15	2.29	1.05	<.05*	-2.17	0.20
Contribution to the good of society	2.36	1.16	2.32	1.11	.72	-0.35	0.03	2.42	1.12	2.20	1.14	0.03*	-2.07	0.19
Job Characteristics														
Intellectually interesting	3.12	0.92	3.15	0.72	.72	0.35	3.18	0.79	3.08	0.80	0.19	-1.29	0.12	3.18
Independence and self-direction	2.74	0.98	2.53	0.91	<.05*	-2.25	0.35	2.74	0.92	2.42	0.93	<.001***	-3.72	0.34
Family Considerations														
Pleasing my family	1.44	1.16	1.49	1.08	.64	0.46	0.04	1.54	1.16	1.38	1.03	.124	-1.54	0.14
Time for family, friends and hobbies	2.63	1.06	2.78	0.96	.12	1.53	0.15	2.72	1.01	2.74	0.98	0.76	0.30	0.02

¹ *p<0.05, ** p<0.01, *** p<0.001

² Guidelines for d: small effect: d = 0.2 - 0.13, ; medium effect: d = 0.13 – 0.26; and large effect: d ≥ 0.26 (Cohen,1973).

Table 5. Means and Standard Deviations for Self-Confidence and Interest in Technical Concepts and Problems for the High and Low Intention, and High and Low Interest Entrepreneurial Groups

	INTENTION							INTEREST						
	(a) High Intention		(b) Low Intention		p-value ¹	t	d ²	(c) High Interest		(d) Low Interest		p-value ¹	t	d ²
Mean	SD	Mean	SD	Mean				SD	Mean	SD				
Confident of Self-Confidence Characteristics														
Lead a team of people	2.71	0.87	2.42	1.04	<.001***	3.02	0.30	2.65	0.90	2.33	1.08	<.01**	-3.42	0.32
Network with potential new colleagues	2.64	0.93	2.39	1.02	<.01**	-2.59	0.65	2.56	0.93	2.35	1.07	<.001***	-2.20	0.20
Technical Concepts and Problems														
Working on a project involving engineering or scientific concepts	2.83	0.88	2.91	0.96	0.37	0.88	0.06	2.95	0.90	2.79	0.97	0.08	-1.73	0.17
Solving complicated technical problems	2.75	1.07	2.88	1.09	0.20	1.28	0.12	2.91	1.01	2.73	1.18	0.08	-1.74	0.16

¹ *p<0.05, ** p<0.01, *** p<0.001

² Guidelines for d: small effect: d = 0.2 - 0.13, ; medium effect: d = 0.13 – 0.26; and large effect: d ≥ 0.26 (Cohen, 1973).

INTENTION: Both measures of self-confidence were statistically significant. In the high intention group, alumni were more confident in their abilities to lead a team of people and to network with potential new colleagues in professional-work settings. While interest in technical concepts and problems were similar for both high and low intention groups, the low intention alumni reported greater interest in working on a project involving engineering or scientific concepts and solving complicated technical problems (though the difference is not statistically significant).

INTEREST: We found similar trends between the high and low interest groups as we did with the high and low intention groups. For self-confidence, the high interest group was more confident in leading a team of people and to network with potential new colleagues in professional-work settings. Again, interest in technical concepts and problems were similar. However, high interest group reported a higher mean interest in working on a project involving engineering or scientific concepts and solving complicated technical problems as compared to the low interest group (though the difference is not statistically significant). This finding was opposite that found with the intention groups.

4.2 Factors that Influence Interest in and Intention to Pursue Entrepreneurial Activities

(RQ2) What factors influence alumni's interest in and intention to pursue entrepreneurial activities?

RQ2 focuses on understanding what factors influence alumni's interest in and intention to pursue entrepreneurial activities. High intention alumni were identified using the following question: *How likely is that you will start a company or an organization in the near future?* This item was 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?* This variable was measured on a 5-point scale ranging from "Not Interested" to "Extremely Interested."

As noted earlier, Table 2 illustrates how individual responses to each measure were assigned to either low or high levels of intention and interest.

Table 6 summarizes selected demographic characteristics for two groups: the high interest-high intention group and all others.

Women represented almost one quarter (23.3%) of the engineering alumni surveyed, and just under one fifth (17.8%) of the high interest-high intention entrepreneurship alumni group. A chi-square test for association was conducted with the variables in Table 5 to investigate their relationship with the high interest-intention groups and all others. There were significant associations with gender, $\chi^2(1) = 2.863$, $p < .05$, and URM, $(\chi^2(1) = 12.827$, $p < .001$). There was a higher proportion of high interest-high intention alumni in both low-middle income and high income levels that was statistically significant ($\chi^2(4) = 11.988$, $p < .01$). Also, there was a significant relationship between engineering alumni who currently hold an engineering position with level of interest and intention ($\chi^2(1) = 7.938$, $p < .01$). Having co-founded or started a company was also significantly related to income status ($\chi^2(1) = 40.357$, $p < .001$).

Table 6. Demographics of the High Interest – High Intention and All Other Groups.

	High Interest High Intention		All Others	
	N=142	29.9%	N=332	70.1%
Sex				
Female	25	17.8%	82	24.8%
Male	117	82.2%	250	75.2%
Total	142	100.0%	332	100.0%
Race				
URM	17	12.7%	12	3.7%
Non-URM	115	87.3%	306	96.3%
Total	132	100.0%	318	100.0%
Family income growing up				
Low income	6	3.9%	17	5.3%
Low-middle income	31	22.1%	54	16.3%
Middle income	49	34.8%	138	41.8%
Upper-middle income	44	30.8%	114	34.1%
High income	12	8.4%	8	2.5%
Total	142	100.0%	331	100.0%
Current position				
An engineering position	94	67.8%	264	79.7%
A non-engineering position	44	32.2%	67	20.3%
Total	138	100.0%	331	100.0%
Major				
Aeronautical & Astronautical	6	3.9%	25	7.6%
Chemical	12	8.1%	36	11.0%
Civil	9	6.2%	25	7.6%
Computer	6	4.1%	15	4.4%
Electrical	15	10.7%	45	13.6%
Engineering	25	17.9%	30	9.0%
Industrial	14	9.8%	20	6.0%
Mechanical	19	13.6%	50	15.2%
Petroleum	3	2.4%	75	22.9%
Other Engineering	33	23.3%	7	2.7%
Total	142	100.0%	328	100.0%
Co-founded or started a company				
Co-founded a company	28	19.7%	9	2.7%
Did not co-found a company	114	80.3%	323	97.3%
Total	142	100.0%	332	100.0%

Sixteen variables were identified from the RQ1 results and from a study identifying factors that were significantly associated with entrepreneurial alumni.⁶ These variables addressed alumni's characteristics in regard to financial security, career advancement, social good, work-life balance

and external motivations. A logistic regression was conducted to ascertain the effects of these variables (Table 7). The logistic regression model was statistically significant, $\chi^2(16) = 104.02$, $p = .000$. The model explained 30.0 percent (Nagelkerke's R^2) of the variance in alumni who showed high interest and high intention in entrepreneurship, and correctly classified 75.1 percent of the cases. Sensitivity was 38.5 percent, and specificity was 90.8 percent. Of the sixteen-predictor variables, thirteen were statistically significant (indicated in bold) and three were not.

Table 7. Logistic Regression Predicting Likelihood of High Interest-High Intention in entrepreneurship.

Variables	<i>B</i>	SE	Wald $\chi^2(1)$	p-value ¹	Odds ratio	95% CI Odds Ratio	
						Lower	Upper
What my peers are doing	0.23	0.10	5.61	<.01**	1.26	1.04	1.52
Experiences in my job	0.12	0.11	1.11	0.29	1.12	0.90	1.40
Having a secure job	-0.54	0.13	15.95	<.001***	0.59	0.45	0.76
Having a job that puts me on the “fast track” for career advancement	0.33	0.12	7.87	<.001***	1.40	1.11	1.76
Desire for additional education and training	0.21	0.11	3.64	<.05*	1.24	0.99	1.54
Discuss skills learned in class	0.24	0.12	3.89	<.05*	1.27	1.00	1.61
Work in a professional engineering environment as an intern or co-op	-0.73	0.27	7.67	<.001***	0.48	0.29	0.81
Importance of engineering techniques – tools	-0.30	0.10	8.96	<.001***	0.74	0.61	0.90
Considering cost – benefits, return on investment	0.22	0.10	4.61	<.01**	1.25	1.02	1.53
Considering sustainability	-0.23	0.11	4.69	<.01**	0.79	0.64	0.98
Considering user needs and interests	0.20	0.11	3.56	<.05*	1.22	0.99	1.51
Has been difficult to build a support network in my organization	0.38	0.11	12.07	<.001***	1.46	1.18	1.80
Lead a team of people	0.34	0.14	6.13	<.001***	1.40	1.07	1.83
Career Satisfaction	-0.15	0.12	1.61	<.01**	0.86	0.68	1.09
Current standard living expectation before and after earned engineering degree	-0.22	0.17	1.77	0.08	0.80	0.57	1.11
Citizenship Status	0.28	0.22	1.71	0.19	1.32	0.87	2.02
Constants	-1.64	0.75	4.86	0.03	0.19		

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

The regression model shows that alumni from the high interest-high intention group were significantly more influenced by “what their peers were doing” while making career decisions (1.25 more times). Moreover, half of the time it was less important to the high interest-high intention group to have “a secure job”. This finding is consistent with the findings from RQ1. For the high interest-high intention group, it was significantly more important to have “A fast track job for career advancement” (1.43 times more important) and a “desire for additional education and training” (1.25 times more important). These findings are consistent with the variables that Duval-Couetil and colleagues identified while selecting variables that lead to high intention in engineering students to co-found their own company.

The high interest-high intention group was 1.27 times more likely to discuss the “skills learned in class apply to real-life engineering practice with their engineering professors.” Moreover, the high interest-high intention alumni were 0.48 times less likely to do a summer term in “a professional engineering environment as an intern-co op.” In their current jobs, the high interest-high intention group more often consider “cost-benefits, return on investment” (1.22 more times), “user needs and interests” (1.22 more times) and less often to consider sustainability (0.76 more times). In addition the high interest – high intention alumni agreed 1.46 times more that it was “difficult to build a support network in their organization.”

With regard to managing people, high interest-high intention alumni were 1.38 times more confident in “leading a team of people” whereas for the factors of “career satisfaction so far” and “citizenship status” did not make a statistically significant difference in the model.

4.3 Past Entrepreneurial Activities, as Related to Future Activities

(RQ3) For engineering alumni who had been entrepreneurs in the past, what activities led them to either become more entrepreneurially-minded or divert to a non-entrepreneurial career path?

RQ3 focuses on understanding the characteristics of engineering alumni who had been entrepreneurs in the past and whether they would continue with their entrepreneurial pursuits or divert to a non-entrepreneurial career path in the future.

For this study, alumni with prior entrepreneurial experience were identified using the following survey question: *In your career path so far, have you started or co-founded your own company?* (Yes/No). Alumni with intentions to engage in future entrepreneurship activities were identified using the following item: *How likely is that you will start a company or an organization in the near future?* This question was measured on a 5-point scale ranging from “Definitely Not” to “Definitely Yes.”

Table 8 illustrates how individual responses to each measure were used to classify respondents as either assigned to either *Entrepreneur or Not an Entrepreneur*.

For the measure, *In your career path so far, have you started or co-founded your own company?* Respondents who answered “yes” were classified as an entrepreneur. Those who answered “no” were classified as not an entrepreneur.

For the measure, *How likely is it that you will start a company or an organization?* Respondents who indicated their likelihood of starting a company or an organization in the near future was “probably not” or “definitely not”, were classified as not an entrepreneur. Those who responded “maybe,” “probably yes,” and “definitely yes” were classified as an entrepreneur.

Alumni who started or co-founded a company were classified as Past Entrepreneurs. Alumni who were Past Entrepreneurs, and responded to “probably yes”, “definitely yes”, and “maybe” to start a company or an organization in the near future were classified as Past and Future Entrepreneurs. Table 9 summarizes selected demographic characteristics for Past Entrepreneurs and Past and Future Entrepreneurs.

Table 8. Classification of Alumni to *Entrepreneur* and *Not an Entrepreneur* Classifications

Question	Response Option	Entrepreneurs Classification
<i>In your career path so far, have you started or co-founded your own company?</i>	Yes	Past Entrepreneurs
	No	Not Past Entrepreneur
<i>How likely is that you will start a company or an organization in the near future?</i>	Definitely Not	Not Past and Future Entrepreneurs
	Probably Not	
	Maybe Probably Yes Definitely Yes	Past and Future Entrepreneurs

Table 9. Demographics of Alumni Who had been Entrepreneurs in Past and Some Who Diverted to a Non-entrepreneurial Career Path.

	Past Entrepreneurs		Past and Future Entrepreneurs	
	N=7	%	N=30	%
Sex				
Female	0	0.0%	3	9.1%
Male	7	100.0%	27	90.9%
Total	7	100.0%	30	80.1%
Race				
URM	0	0.0%	5	16.4%
Non-URM	7	100.0%	24	83.6%
Total	7	100.0%	29	100.0%
Current position				
An engineering position	5	61.8%	18	61.6%
A non-engineering position	2	38.2%	11	38.4%
Total	7	100.0%	29	100.0%

4.3.1 Career Decision-Making for Past Entrepreneurs, and Past and Future Entrepreneurs

In the PEARS dataset, factors related to participants' career paths were measured through the three items about the importance to one's career-decision making so far, on a 5-point scale ranging from *Not Important* to *Extremely Important*. These items include: having a well-paying job; having a job that gives me time for family, friends and hobbies; and having a job that helps me figure out what I am really interested in. A Mann-Whitney U test was conducted to evaluate the hypothesis that these three items were factors that influenced whether entrepreneurial alumni would either continue on or divert from an entrepreneurial pathway.

The results indicate that past entrepreneurs with no interest in pursuing entrepreneurship in the future had significantly higher mean scores than the co-founders with future entrepreneurial interests in regard to having a well-paying job and having a job that would help them to figure out what they were really interested in. Even though the means were not significantly different, past and future entrepreneurs reported higher means than past entrepreneurs in regard to being interested in having a job that gave them time for family, friends and hobbies.

Table 10. Means and Standard Deviations of Career Decision-Making, Skills and Context in Current Work, and Confidence Variables for Past Entrepreneurs and Past and Future Entrepreneurs

	Past Entrepreneurs		Past and Future Entrepreneurs		P-value ¹	t	d ¹
	Mean	SD	Mean	SD			
Career Decision-Making							
A well paying job	3.41	0.54	2.39	0.98	<.01**	2.45	1.28
Time for family, friends and hobbies	1.88	0.74	2.74	1.00	0.05	-1.95	-1.63
A job that helps me figure out what I am really interested in	2.49	1.00	1.88	0.74	<.05*	-2.30	0.69
Skills and Context in Current Work							
Having a mentor who offers advice and encouragement at my organization	3.29	1.04	3.39	1.17	0.08	0.22	-0.09
My organization allow me to show off my talents	3.87	0.36	3.20	0.70	<.01**	-0.95	1.20
Confidence in Professional-Work Settings							
Lead a team of people	2.52	0.71	2.90	1.03	0.35	-0.94	-0.42
Resolve conflicts with team members	2.01	1.00	2.75	0.84	<.05*	-2.09	-0.80

¹ *p<0.05, ** p<0.01, *** p<0.001

² Guidelines for d: small effect: d = 0.2 - 0.13, ; medium effect: d = 0.13 – 0.26; , and large effect: d ≥ 0.26 (Cohen, 1973).

4.3.2 Measures of Skills and Context in Current Work of Engineering Alumni

In the PEARS dataset, we measured skills and context in current work through extent of agreement with two items: *I have a mentor who offers advice and encouragement at my organization*; and *the assignments that I am given in my organization allow me to show off my talents*. These items were measured on a 5-point scale ranging from *Disagree Strongly* to *Agree Strongly*. A Mann -Whitney U test was conducted to evaluate the hypothesis that “having a mentor who offers advice and encouragement at my organization,” and “the assignments that I am given in my organization allow me to show off my talents” were factors that influenced alumni with past entrepreneurial experience to either continue or divert from an entrepreneurial pathway (Table 10).

The results from the test indicated that past entrepreneurs had significantly higher mean scores than the past and future entrepreneurs in regard to “the assignments that I am given in my organization allow me to show off my talents.” There was no statistically significant differences found between past entrepreneurs and past and future entrepreneurs in regard to “having a mentor who offers advice and encouragement at my organization.”

4.3.3 Confidence in Professional-Work Setting of Engineering Alumni

Confidence in the application of skills in a professional-work setting was measured through two items – leading a team of people and resolving conflicts with team members. The responses were measured on a 5-point scale ranging from *Not Confident* to *Extremely Confident*. A Mann-Whitney U test was conducted to evaluate the hypothesis that “leading a team of people,” and “resolve conflicts with team members” were factors that influenced entrepreneurial alumni to either continue on or divert from an entrepreneurial pathway.

The results in Table 10 indicate that the past and future entrepreneurs who were interested in continuing on the entrepreneurial path had significantly higher means than past entrepreneurs in regard to “leading a team of people” and “resolving conflicts with team members” These results are consistent with RQ1.

5. Discussion and Conclusion

This study focused on a series of analyses based on levels of interest in and intention to pursue entrepreneurial activities. Prior research conducted with alumni and other populations have largely focused on either only entrepreneurial interest or entrepreneurial intention.^{3,4,5} In contrast, this research explored entrepreneurial intention, entrepreneurial interest, and the combination of the two in order to draw meaningful conclusions about the factors that influence alumni’s intentions and interest in pursuing entrepreneurial activities.

Our first research question explored how engineering alumni with high intentions and high interest in pursuing entrepreneurial activities compared with peers with low entrepreneurial intention and interest. The size of the high interest group was almost double the size of the high intention group. However, this finding was not unexpected since interest typically precedes intention. Both the high intention and high interest groups had a higher representation of URM alumni than in the overall sample. Workforce organizations such as the U.S. Small Business Administration have also observed growth in minority-owned businesses and agencies such as the Minority Business Development Agency within the U.S. Department of Commerce have

pledged their support for ongoing economic opportunities. Support for fostering entrepreneurial aims among URM students in higher education has been seen in initiatives such as the Historically Black Colleges and Universities Innovation and Entrepreneurship Collaborative.¹²

Similar support for women interested in entrepreneurship is sorely needed. Women were more likely than men to be represented in the low intention and low interest groups. This noticeable lack of a female presence across the high groups is consistent with the low representation of women students in engineering in general, and the findings of other studies of entrepreneurial involvement.¹³ While there are commitments from organizations such as the U.S. Small Business Administration's Office of Women's Business Ownership to foster the participation of women entrepreneurs in the economy, there is a critical need for corresponding programs and interventions at the college and university levels.

The high intention and high interest groups included most of the alumni who co-founded or started a company. However, within these groups, there were fewer engineering alumni who reported currently holding engineering positions as compared to the low intention and low interest groups. Understanding the rationale behind this result warrants further exploration – is the perception that one is either an entrepreneur or an engineer but it is not possible to be both? Is holding an engineering position not conducive to entrepreneurship? Additional findings about job characteristics identify some possible pathways for investigation. The alumni in the low intention and low interest groups were more likely to look for a secure job than the high interest and high intention groups. The high interest group expressed greater interest in a well-paying job than the low interest group (this same distinction was not seen between the high-low intention groups). However, both the high interest and high intention groups were more likely to look for jobs that support independence and self-direction, and reported greater confidence in leading a team of people and networking with potential colleagues in professional-work settings.

These findings provide some insights into not only the kinds of job characteristics that might appeal to alumni with entrepreneurial leanings but also the types of knowledge and skills that are needed in order to allow these individuals to advance and grow in uncertain work environments with lower job security. Whether these individuals are invited to apply or if they self-select and seek out these positions, the characteristics for each of these groups led us to focus our second research question on membership in a group defined as having high interest in and high intention to pursue entrepreneurship. The outcomes of the logistic regression model found that alumni's characteristics in regard to financial security, career advancement, social good, work-life balance and external motivations were significant predictors of entrepreneurship activity. Some of the career advancement factors that were strong predictors of entrepreneurial activities were having a fast track job, and a desire for additional education and training.

In order to better understand the influence of prior experience on future entrepreneurial endeavors, in our last research question, we investigated alumni who had started or co-founded a company in the past in order to understand the factors that influenced their decision to pursue or not to pursue entrepreneurial activities in the future. Of the 37 alumni who had co-founded or started a company in the past (Past Entrepreneurs), 30 of them were willing to start a company or become co-founders again in the future (Past and Future Entrepreneurs). Surprisingly, all women with prior entrepreneurship experience expressed interest in and intention to continue in the

entrepreneurial path. Less surprising but still worth noticing is that all of the URM alumni with past entrepreneurial experience were willing to pursue entrepreneurial ventures in the future (both women and URM fell into the Past and Future Entrepreneurs group). The Past and Future Entrepreneurs group placed lower importance on having a well-paying job that helped them figure out their interests. Past and Future entrepreneurial alumni also possessed greater confidence in their abilities to resolve conflicts with team members in a professional-work setting and were less likely to agree that an organization's assignments would allow them to show off their talents.

Overall, the results from these three research questions reiterated and repeatedly highlighted several fruitful areas for future inquiry including both the characteristics of individual alumni as well as the features of jobs that might appeal to and foster entrepreneurial activities. This includes for example, the professional and interpersonal skills that contribute to the self-efficacy and self-confidence that is necessary for engineering alumni to successfully explore entrepreneurship opportunities. These alumni also appear to choose positions that would support greater independence and career advancement.

Collectively, these findings begin to inform the development of a framework for comprehensively understanding the characteristics of entrepreneurial engineering alumni as well as the kinds of jobs they seek in order to support their entrepreneurial interests. While in its early stages, such a framework can assist engineering education researchers in identifying patterns in behavior and the kinds of undergraduate experiences that would contribute to engineering students' entrepreneurial directions after graduation and their transition from academic settings into highly innovative work environments.

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