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The Roots of Entrepreneurial Career Goals among Today's Engineering Undergraduate Students

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Abstract

This study examines the roots of entrepreneurial career goals among today's U.S. undergraduate engineering students. Extensive literature exists on entrepreneurship education and on students' career decision making, yet little work connects the two. To address this gap, we explore a sample of 5,819 undergraduate engineering students from a survey administered in 2015 to a nationally representative set of twenty-seven U.S. engineering schools. We identify how individual background measures, occupational learning experiences, and socio-cognitive measures such as self-efficacy beliefs, outcome expectations, and interest in innovation and entrepreneurship affect students' entrepreneurial career focus. Based on career focus, the sample is split into "Starters" and "Joiners" where Starters are students who wish to start a new venture and Joiners are those who wish to join an existing venture. Results show the demographic, behavioral, and socio-cognitive characteristics of each group. Findings suggest that relative to Joiners, Starters have stronger occupational self-efficacy beliefs which are driven by higher interests in innovation-related activities and ascribing greater importance to involvement in innovation practices early in their careers. Additionally, the significant influence of particular learning experiences is discussed. These results have implications for engineering and entrepreneurship education.

1.0 Introduction

While the societal and economic benefits of a healthy entrepreneurial culture and ecosystem are widely acknowledged (Adner & Kapoor, 2010; Delgado, Porter, & Stern, 2010; Feldman, 2014; Porter, 1998), less is known about the attributes and pathways of entrepreneurs, especially entrepreneurs with backgrounds in engineering. This study makes use of data collected as part of the Engineering Majors Survey (EMS), a nationally-representative survey administered in 2015 across 27 U.S. universities with a final sample size of 5,819 engineering undergraduates. This study is grounded in the theoretical framework of Social Cognitive Career Theory (SCCT) by Lent, Brown and Hackett (1994). This framework uses socio-cognitive factors to map the complex process of career choice and shows how it is linked to factors such as background characteristics and contexts. The EMS included constructs addressing these socio-cognitive factors and contextual sources of influence. We connect this model to recent findings about the roots of engineering students' intentions to start new ventures (Lintl *et al.*, 2015) and research on students' innovation and entrepreneurial skills (Duval-Couetil & Dyrenfurth, 2012; Dyer, Gregersen, & Christensen, 2011). In this study, we ask who are the entrepreneurs of tomorrow, what motivates them, and what learning experiences influence their career pathways.

2.0 Starter or Joiner?

An aim of this study is to understand students' entrepreneurial intent, specifically asking *How varied are entrepreneurial career goals among today's undergraduate engineering students? (RQ 1)*

We begin by considering what entrepreneurial intent is. There exist many definitions of entrepreneurship, such as the activity of starting a business, taking on risk in the hope of profit, or the discipline of managing innovation in the marketplace. Extending from these ideas, we look at entrepreneurial intent as the motivation to start a new venture. Lintl *et al*. studied students' entrepreneurial intent in their paper, "Starter or Joiner, Market or Socially-Oriented: Predicting Career Choice among Undergraduate Engineering and Business Students" (2015). This study differentiated its sample based on career choice. “Starters” were most interested in starting a business or organization after graduation, and “Joiners” were most interested in joining an existing business or organization after graduation. Lintl *et al.* found that students who are Starters are “new seeking” and “iconoclastic”; they have higher “domain self-efficacy” compared to students who are considered Joiners; and gender differences appeared to play a major role, with women being significantly more likely to be Joiners than men. Lintl *et al*. also compared engineering to business majors. Their findings show that while more than 30% of the engineering majors expressed a career choice involving “starting something,” in general engineering majors were less likely to become Starters than were fellow students with a business focus (2015). This study builds upon the work of Lintl *et al*., and thus we will follow the same distinctions of “Starters” and “Joiners,” as described in more detail in Section 3.3.6.

2.1 Entrepreneurship and Innovation

“Successful innovators don’t wait until the Muse kisses them and gives them a bright idea” (Drucker, 2015, p. 41), rather research shows that successful innovation and entrepreneurship is linked to particular behaviors and skills. But what are the behavioral skills of successful entrepreneurs? Dyer, Gregersen, and Christensen (2011) illustrate important behavioral and cognitive skills for the innovation process in Figure 1.

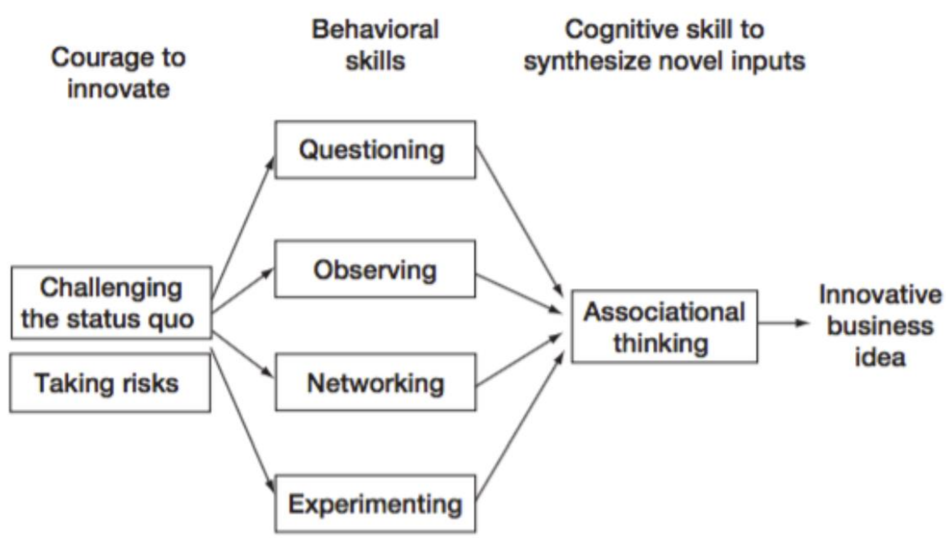

Figure 1: The innovator’s DNA for generating innovative ideas by Dyer *et al*. (2011).

Their model is based on key elements of the innovation processes. Dyer *et al.* conclude that associational thinking is key to generating innovative ideas, and that this skill can be trained through frequent engagement in “questioning, observing, networking, and experimenting” (p. 10). “Innovation begins with the activation of some person or persons to sense or seize a new opportunity” (Kanter, 1988, p. 173) and this can be learned. Innovation is a methodical discipline; it can be taught, learned and applied systematically. TRIZ, SCRUM, and Design Thinking are innovation methods that can be used to teach and enable innovative behavior and thinking (Duval-Couetil & Dyrenfurth, 2012; Osorio, 2011; Dym, Agogino, Eris, Frey, & Leifer, 2005). “Innovation consists of a set of tasks carried out at the micro level by individuals and groups... within organizations. These micro processes are in turn stimulated, facilitated, and enhanced – or the opposite – by a set of macro-level conditions" (Kanter, 1988, p. 1).

2.2 The socio-cognitive process of setting career goals: Social Cognitive Career Theory

Building on our first research section, we also consider how engineering students are setting career goals around entrepreneurship. Why do they want to become starters or joiners? More concretely: *How do innovation measures and past experiences affect the entrepreneurial focus of engineering students? (RQ 2)*

To answer this question, this study is built on Social Cognitive Career Theory (SCCT). Lent *et al*. (1994) developed SCCT to understand how career goals and ultimately choices are developed. SCCT "emphasizes the means by which individuals exercise personal agency in the career development process... and factors that enhance or constrain agency... [such as] self-efficacy, expected outcome, goal mechanisms and... other person (e.g. gender), contextual (e.g. support system), and experiential/learning factors" (Lent *et al.*, 1994, p. 79), as depicted in Figure 2. Social Cognitive Career Theory is based on Social Cognitive Theory by Bandura (1986) and relates to similar socio-cognitive constructs. Lent *et al*. present different interlocking models, which center around self-efficacy, outcome expectations and goals to illustrate the extension of Social Cognitive Theory to their model of career choice. Social Cognitive Theory also takes individual dispositions into account as external influences. The SCCT framework has been used successfully in many studies to research the pathways and career goals of students (Brunhaver, Sheppard, Antonio, & Barley, 2015) and provides a reliable theoretical framework for the current study on entrepreneurial career goals of today's engineering undergraduates.

2.2.1 What are the socio-cognitive factors, driving entrepreneurial intent?

On the micro level, the model illustrates one's socio-cognitive process of setting a career goal. The current study focuses on students' innovation and entrepreneurial self-efficacy, their outcome expectations of an engagement in this field, and their interest in innovation and entrepreneurship. We expect these factors to be major predictors of an entrepreneurial career choice. Paths 1 and 2 in Figure 2 show how one's self-efficacy and outcome expectations influence the formation of interests and thereafter the formation of activity goals. In reference to Bandura (1986) self-efficacy is the "people's judgments of their capabilities to organize and execute course of action required to attain designated types of performances" (p.391). Therefore, self-efficacy percepts are an essential factor for one's choice of behavior. Bandura (1989) shows that such self-efficacy beliefs are among the most important determinants of one's personal agency. Hackett and Betz (1981) were the first to apply this construct to their research on career choice and their findings affirm that self-efficacy is a predictive factor for career choice. To date, substantial research on career choice relies on self-efficacy as an important factor (Bandura, 1977; Bandura, 1989; Brunhaver *et al*., 2015; Hackett & Betz, 1981; Lent & Brown, 2006). Findings show that "people form enduring interests in activities in which they view themselves to be efficacious and in which they anticipate positive outcomes" (Lent *et al*., 1994, p. 89).

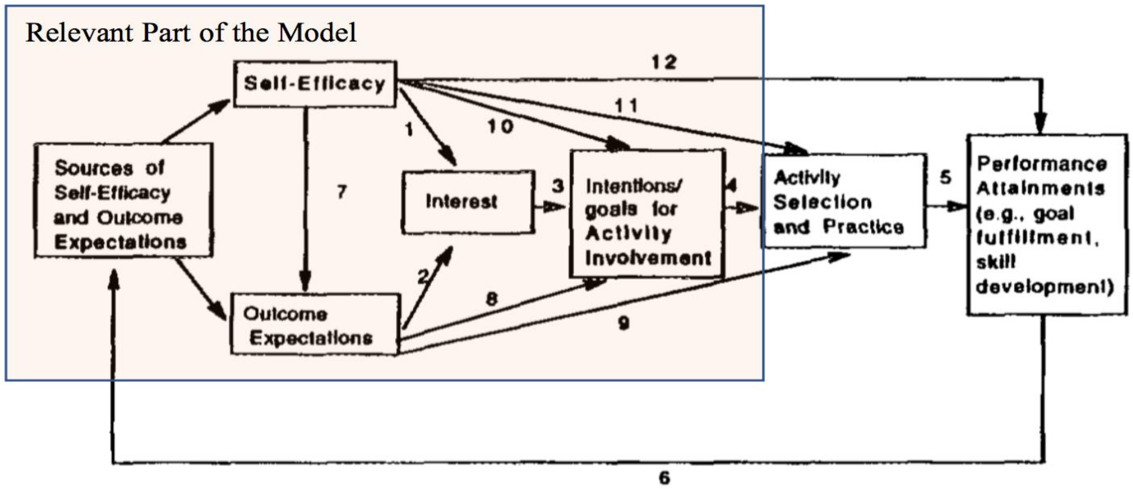

Figure 2. The process of making a career choice on the micro level illustrates the relationship between self-efficacy, outcome expectations, interests and goals (Model from Lent et al 1994).

The SCCT model shows that interests lead to intentions or goals (path 3). Career goals are also reflective of self-efficacy and outcome expectations (path 8, path 10). Lent *et al*. (1994) differentiate between direct influences from self-efficacy and outcome expectations to goals and indirect influences, which are mediated through interests. This distinction refers to the idea of intrinsic motivation – when someone is motivated to pursue a certain goal because of her/his inherent personal interest – and extrinsic motivation – when someone is not particularly interested in obtaining a goal but her/his self-efficacy beliefs tell her/him that it is achievable and the expectations of a rewarding outcome are high. Eventually following a goal or intention results in the selection and practice of related activities (path 4). An actual career choice is determined by a choice goal: "By setting goals, people help to organize and guide their behavior […] a goal can be defined as the determination to engage in a particular activity or to effect a particular future outcome […] Such concepts as career choice are all essentially goal mechanisms" (Lent *et al*., 1994, p. 85).

The focus of this study is on career goals (instead of career decisions) since the participants are students who had not yet made a career decision. Resulting performance attainments such as success or failure are the results of this engagement (path 5). Different levels of attainment lead to a constant revision of a person's self-efficacy and outcome beliefs in a feedback loop (path 6). "A robust sense of efficacy may help sustain performance even in endeavors that offer high rate of failure or rejection" (Lent *et al.*, 1994, p. 101). Entrepreneurship is a discipline that is marked by uncertainties and risks. Failure and rejection play a major role. Therefore, this study centers on the roles of innovation and entrepreneurial self-efficacy and outcome expectations in the decision-making process. Taken together, the above research suggests that an interest in innovation is a major predictor of an innovation-related career goal. The students' interest functions as a mediator. The effects of students' self-efficacy on the innovation-related career goal is mediated via their interest. The mediated effect accounts for intrinsic motivation, while the direct effect of self-efficacy to career goals expresses extrinsic motivation. Students with a strong self-efficacy, positive outcome expectations and interests in innovation and entrepreneurship will more likely set a career goal with an entrepreneurial focus.

2.2.2 Setting a Career Goal: External influences on the macro level

While the SCCT model above is focused on individuals' dispositions fostering an entrepreneurial career goal, we also want to consider external influences that may drive an entrepreneurial spirit. The SCCT model is enhanced by adding complexity and context to the basic micro model. Lent *et al.* (1994) add " a second layer" (p. 101) to the model, as shown in Figure 3.

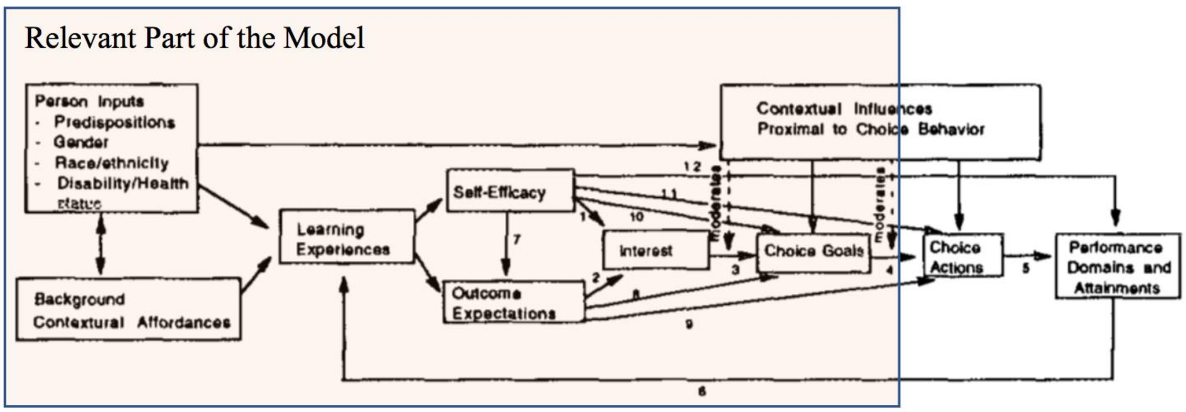

Figure 3. External predictors are added as a macro layer to the process of making a career choice. Learning experiences are a major predictor for self-efficacy and outcome expectations. Person inputs, individual backgrounds and contextual affordances are taken into account as predictors of learning experiences (Model from Lent et al 1994).

Learning experiences as sources of self-efficacy and outcome expectations are added to the model, and herein lies the focus of this study. Person Inputs and resulting Background Contextual Affordances (e.g. access to opportunities) influence learning experiences.

2.2.3 Learning Experiences

Learning experiences as they contribute to students' innovation self-efficacy and innovation outcome expectations are especially relevant for the career choice process. "Self-efficacy beliefs are largely determined and modified by four informational sources: personal performance accomplishments, vicarious learning, social persuasion, and physiological states and reactions" (Lent *et al.*, 1994, p. 102). The current study is focused on students' innovation and entrepreneurship related learning experiences in the academic surrounding e.g. coursework and extracurricular experiences. "Self-efficacy beliefs [and] outcome expectations are generated through direct and vicarious experiences with educational and occupationally relevant experiences" (p. 103). Brunhaver *et al.* (2015) confirm this assumption and the important role of learning experiences for students' career choices. It is concluded that students' learning experiences at the university in the (occupational relevant) fields of innovation and entrepreneurship are positive sources for the formation of innovation self-efficacy and outcome expectations. Consequently, we assume that students who engage in innovation and entrepreneurship relevant learning experiences are more likely to become Starters.

In summary, the research questions addressed in the current study are as follows:

(RQ 1) *How varied are entrepreneurial career goals among today's undergraduate engineering students?*

(RQ 2) *How do innovation measures and past experiences affect the entrepreneurial focus of engineering students?*

3.0 Method

3.1 The Engineering Majors Survey

The Engineering Majors Survey (EMS) was administered in 2015 to engineering students across a nationally-representative sample of 27 U.S. colleges and universities. The survey was designed to be a 10-minute online questionnaire about students' attitudes, experiences, and goals relating to innovation, entrepreneurship, and engineering. The survey contained questions on students' interests, self-efficacy, outcome expectations for performing certain tasks, learning experiences, background and contextual characteristics (e.g. gender, race/ethnicity, and major). The EMS institutional sample represents a 2x2x2 stratified quasi-random sample of about 350 U.S. engineering schools (see Gilmartin *et al*., 2017). A total of 7,197 students responded to the EMS from which 6187 self-reported to be in the target group of "Juniors" and "Seniors". The majority of respondents were male students (70%) and 14% of respondents belong to an underrepresented minority (URM). For 16% of the respondents neither mother nor father completed an Associate or higher degree in college education. These demographic data are summarized in Table 1.

Table 1: Demographics of engineering majors survey (EMS) participants

Class		
	Juniors	47%
	Seniors	41%
	Fifth-year seniors or more	12%
Gender		
	Male	70%
	Female	30%
Students with URM status		14%
Age (in years)		22.24
First generation college students		16%

3.2 Multiple Imputation for Chained Equations

The EMS was designed such that students could decide not to answer any question. This means that some data was missing for some respondents. There exist various techniques for dealing with missing values. We applied the "Multiple Imputation for Chained Equations" technique (MICE, see Allison, 2003, 2011). In contrast to the "Listwise Deletion" technique, MICE does not discard large amounts of valid information. Before MICE was applied to the EMS, a “completeness test” was conducted to ensure that only missing data for those observations is imputed where enough knowledge of the respondent was available.

Therefore each observations had to contain at least five of ten important content questions in order to be considered in the MICE procedure. Some 5,819 observations passed this test out of the base data with 6,187 observations. Of these 5,819 observations only 3.5% data points were missing: a decrease of almost 10 percentage points from the 13% missing data in the 6,187 data set as mentioned above. Those 3.5% were then imputed with MICE leading to a fully completed data set with 5,819 observations (students).

Table 2: Comparison of Multivariate Imputation by Chained Equations (MICE) and Listwise Deletion

Method	**Completeness**	**N**
Listwise Deletion	100.0 %	4789
MICE	96.5 %	5819
Original Data Set	87.0 %	6187

3.3 Measurements

The variables contained in the EMS that embody the SCCT and that are relevant to the current study are presented in the following section. A summary of all variables is presented in Appendix A.

3.3.1 Innovation Self-Efficacy

The innovation self-efficacy scale is composed of six items which were adapted from Dyer, Gregerson, & Christensen (2008). The scale is designed to map the students’ self-efficacy regarding the innovative behaviors and abilities of “questioning”, “observing”, “experimenting”, “idea networking” and “associative thinking” as described in Figure 1 (Items: Ask a lot of questions; Generate new ideas by observing the world; Experiment as a way to understand how things work; Connect concepts and ideas that appear, at first glance, to be unconnected; Build a large network of contacts with whom you can interact to get ideas for new products). Students were asked “How confident are you in your ability to do each of the following at this time?” and ranked their answers on a five point Likert scale from “not confident” to “extremely confident” (on a scale from 0 to 4). The scale was presented and discussed as ISE.6 construct in a recent technical report on the EMS (Gilmartin, S., et al, 2017). The construct shows a Cronbach’s alpha of 0.79, and the score for each students’ innovation self-efficacy is calculated by taking the average of these six items.

3.3.2 Venturing self-efficacy

The item is adapted from Lucas *et al.*’s (2009) Venturing Self-Efficacy scale. Schar *et al.* (2014) found that there is a strong correlation between this item and engineering students’ entrepreneurial intent. Students were asked: How confident are you in your ability to take the steps needed to place a financial value on a new business venture? Again they could rate their answer on a 5-point Likert scale.

3.3.3 Innovation Outcome Expectations

The scale to measure students' innovation outcome expectations is designed to coordinate with the first item of the innovation self-efficacy scale ("ask a lot of questions"). Students were asked about the expected outcomes from this indicator of innovative behavior: "Imagine the work you will be doing in the first year after you graduate. Estimate what will happen if you 'ask a lot of questions' in this work". Respondents could rank their answers on a five point Likert scale. The Cronbach's alpha for this construct is 0.70, and the score for innovation outcome expectations is calculated as the average of the four items. Two items are recoded first since the innovation outcome expectations are best designed as two sub-scales to combine negative and positive outcome expectations (Singh *et al.*, 2013).

3.3.4 Interest in Innovation and Entrepreneurship

The students interest in innovation and entrepreneurship scale consists of five items. Respondents were asked about their interest in engaging in certain innovative behaviors and could rank their interest on a five point Likert scale from "very low interest" to "very high interest". The first item "*Experimenting in order to find new ideas*" is designed to coordinate with a similarly worded item in the innovation self-efficacy scale and with the first two items in the career goals around innovative work measure, as explained below. The item focuses on the idea-generation aspect of innovation. The item "*Conducting basic research on phenomena in order to create new knowledge*" emphasizes the idea that innovation often originates in an academic or scholarly surrounding (Eesley, 2011; Eesley & Miller, 2012). The following three items are typical steps in the post-idea-generation phase of innovation: "*Giving an elevator pitch or presentation to a panel of judges about a new product or business idea*", "*Developing plans and schedules to implement new ideas*" and "*Finding resources to bring new ideas to life*". They reflect entrepreneurial interests (Duval-Couetil & Dyrenfurth, 2012; J. Dyer *et al.*, 2011; Sheppard *et al.*, 2015). The items *"Working on products, projects, or services that address societal challenges"* and "*Working on products, projects, or services that have significant financial potential"* refer to the differentiation into market and socially oriented innovation and entrepreneurship as proposed by Lintl *et al*. (2015). The calculation of the Cronbach's alpha leads to a result of 0.78, and thus the score of innovation interests is calculated by taking the average of the seven items.

3.3.5 Learning Experiences

Learning Experiences are split into different sets of variables, each consisting of multiple categorical dummy coded items. Students were asked about the content of their coursework at university in the field of innovation and entrepreneurship, and about various extra-curricular activities that have been shown to be predictive of innovation self-efficacy and outcome expectations. The selection of items to measure learning experiences at the university is informed by Gilmartin, Shartrand, Chen, Estrada, and Sheppard (2014), where they analyzed entrepreneurship programs in the United States. The selection of extracurricular activities is informed by literature and survey instruments relevant to innovation self-efficacy and outcome expectations (Epicenter, 2015, 2016; "PEARS - Pathways of Engineering Alumni Research Survey," 2007; Sheppard *et al.*, 2010).

3.3.6 Classification of Starters and Joiners

Starters and Joiners were identified based on two 5-point Likert-Scale items on the job target question (Q20, see Appendix A), "How likely is it that you will do each of the following in the first five years after your graduate". The first item was q20gsfor - "Found or start your own for-profit organization" and the second item was q20hsnon - "Found or start your own nonprofit organization" with possible answers (0) "Definitely will not" to (4) "Definitely will". Six other items were part of this question and they are summarized in Appendix A. If the respondent answered (4) or (3) ("Definitely or Probably will" to either one of these two questions the respondent was identified as a Starter. If the respondent answered (0) or (1) "Definitely or Probably not" to either one of these two questions (and not (3) or (4) to the other question) the respondent was considered to be a Joiner. In total, 5,089 students were identified as a Starter or Joiner. All other students that marked (2) "Might or might not" to both questions were not marked as Starter or Joiner, and were pulled out of the sample (703 participants).

Table 3: Starters (n=806) divided by for-profit or nonprofit orientation

Starters (n=806)	n
Only market-orientated	487
Only socially-orientated	79
Market and socially-orientated	240

In accordance to Lintl *et al.*, we also distinguished between market-orientated Starters ("Found or start a for-profit organization") and socially-orientated Starters ("Found or start a nonprofit organization"). This resulted in 806 Starters from which 487 were only market-orientated, 79 were only socially-orientated and 240 were both, market- and socially-orientated. 4283 students were marked as Joiners (see Table 3).

Table 4: Job targets of engineering students with high and low entrepreneurial focus

Job targets	Join Small Business or Start-up (asbus)	Join Medium or Large Business (blbus)	Join Non-Profit Organizat ion (cnon)	Join Gov, Military or Public Ageny (cgov)	Work as Teacher K-12 (etch)	Work as Faculty Member (fcoll)	**Found or Start For-Profit Org. (gsfor)**	**Found or Start Non-Profit Org. (hsnon)**
Starters total (n=806)	0.58	0.76	-0.36	-0.18	-1.04	-0.67	**1.01**	**-0.10**
Market (only)-orientated	0.81	1.04	-0.56	-0.15	-1.13	-0.76	**1.42**	**-0.67**
Socially (only)-orientated	0.17	0.51	0.30	-0.22	-0.80	-0.46	**-0.58**	**1.08**
Joiners (n=4283)	0.57	1.50	0.01	0.53	-0.75	-0.48	**-0.65**	**-0.73**
Others (n=703)	0.53	1.09	-0.10	0.06	-0.96	-0.61	**0.24**	**-0.25**

This classification strategy was used to calculate the mean-deviated scores for Starters (in total, as well as market- and socially-orientated) and Joiners for each item of the job target question, as summarized in Table 4. Mean-deviated scoring involves taking the mean of an entire item (e.g. join a nonprofit organization, cnon) and subtracting the mean from every sample value. This strategy allows us to identify differences between job target questions where both, Starters and Joiners express a strong affinity (e.g. for joining a medium or large business). Thus, a sub-group with a positive mean-deviated score (e.g. Socially (only)-orinteded Starters for joining a nonprofit organization), indicates this groups above average preference for this item. Joiners have the highest mean deviated score (1.50) for working as an employee for a medium or large size business (bibus). In general, Starters tend more towards joining a small (0.58), medium or large size business (0.76), than to start a nonprofit organization (-0.10). This effect results from the unevenly distributed number of market- and socially-orientated Starters. Socially-orientated Starters tend more towards joining a nonprofit organization as an employee (0.30), starting a nonprofit (1.08) or working for a large size business (0.51) than to join a small business or start-up company (0.17) or start a for-profit organization (-0.58). Market-oriented Starters tend more towards founding or starting a for-profit organization (1.42), and joining a medium or large size business (1.04), than to found or start a nonprofit (-0.67), or join a nonprofit organization (-0.56). These results provide confidence that the proposed classification strategy is a valid method for clustering Starters and Joiners, in that it distinguishes between career goals of these groups.

4.0 Results by Research Question

RQ 1: How varied are entrepreneurial career goals among today's undergraduate engineering students?

The job target to be Starter highly differs between male and female students. As shown in Table 5, only 17% of Starters are female, as compared with 35% of Joiners being female; this is a significant difference (p < .00, phi = .12). Furthermore, 20% of Starters are students that belong to underrepresented minorities, versus 12% for Joiners (p < .00, phi = .09).

Table 5: Demographics of Starters and Joiners

		Starters (n=806)	Joiners (n=3397)	p-value	d/phi	
Class						
	Juniors	50%	48%			
	Seniors	38%	40%	0.01	0.09[1]	
	Fifth-year seniors	12%	12%			
Gender						
	Male	83%	65%			
	Female	17%	35%	0.00	0.12[1]	*
Students with URM status		20%	12%	0.00	0.09[1]	
Age (years)		22.85	22.08	0.00	0.21[2]	*
First generation college students		20%	15%	0.00	0.05[1]	

[1] Phi significance levels: *>.10 (weak effect), **>.30 (medium effect), ***>.50 (strong effect)
[2] Cohen's d significance levels: *>.20 (weak effect), **>.50 (medium effect), ***>.80 (strong effect)

An important difference also appears in the average age of Starters (22.85 years) versus Joiners (22.08 years). This difference is significant with a p-value of <.00 and a Cohen's d effect size of 0.2 (a weak affect). In addition, some 20% of Starters are also first generation college students, versus 15% of Joiners (p-value < .00, phi = .05). There are no significant differences between Starters and Joiners to be a Junior or Senior (p-value = .01, phi = .09).

RQ 2: How do innovation measures and past experiences affect the entrepreneurial focus of engineering students?

Among the 20 extra- and co-curricular activities during college that were asked in the EMS survey, there were only four experiences that revealed highly significant effect sizes (phi > .10) between Starters and Joiners, as summarized in Table 6. First, the experience to participate in a business or entrepreneurship club was reported by 17% of Starters versus only 4% of Joiners (p-value < .00, phi = .16). Second, 11% of all Starters versus 4% of all Joiners participated in a business plan, business modeling or elevator pitch competition (p-value < .00, phi = .13). Moreover, 6% of all Starters took part in a social entrepreneurship or innovation competition whereas only 1% of all Joiners did the same (p-value < .00, phi = .11). 10% of all Starters had already gained experience in starting or co-founding a for-profit or nonprofit organization, versus 1% for Joiners (p-value < .00, phi = .20). All other college experiences did not show significant differences between Starters and Joiners. In general, Starters are more active in all college and learning experiences, and show more willingness to participate in extracurricular experiences. For example, the comparisons are .35 (.19), .28 (.22) (p-value < .00) for Starters and Joiners at the high school level, and .59 (.21), .55 (.23) (p-value < .00) for Starters and Joiners at the college level. In general, Starters are more active in all college and learning experiences and show more willingness to participate in extracurricular activities.

Table 6: Significant differences in college and learning experiences between Starters and Joiners

	Starters	**Joiners**	**p-value**	**d/phi**	
College Experiences					
Participate in business or entrepreneurship club (q12abclbr)	0.17	0.06	0.00	0.16 (1)	*
Business plan, business model or elevator pitch competition (q12gbcomr)	0.11	0.04	0.00	0.13 (1)	
Social entrepreneurship / innovation competition (q12iscomr)	0.06	0.01	0.00	0.11 (1)	*
Starting or co-founding an organization (q12tstor)	0.10	0.01	0.00	0.20 (1)	*
Learning Experiences					
Discussed ideas with faculty member (q13cnew)	1.33	0.59	0.00	0.76 (2)	**
Discussed ideas with other students (q14cnew)	2.52	1.47	0.00	0.86 (2)	***

College Experiences are measured as dummy variable 0 (no) and 1 (yes)

Learning Experiences are measured on a 0-4 Likert Scale with responses 0 (Never) to 4 (Very often)

(1) Phi significance levels: *>.10 (weak effect), **>.30 (medium effect), ***>.50 (strong effect)
(2) Cohen’s d significance levels: *>.20 (weak effect), **>.50 (medium effect), ***>.80 (strong effect)

Among the six survey items on learning experiences and social contexts, the experience to discuss new design or business ideas was a significant differentiator between Starters and Joiners. Starters discussed ideas with faculty members (q13cnew) and other students (q14cnew) significantly more often than Joiners (p-value < .00, Cohen’s d = .76 for q13cnew and d = .86 for q14cnew). In general, the results show that the barrier to discuss new ideas with other students is lower than to discuss them with faculty members.

Table 7: Differences in innovation measures between Starters and Joiners

Scale	Starters	Joiners	p-value	Cohen's d [1]	
Venturing self-efficacy	2.27	1.26	0.00	0.89	***
Innovation self-efficacy	2.92	2.48	0.00	0.60	**
Innovation outcome expectation	2.72	2.67	0.07	0.08	
Innovation interests	2.98	2.34	0.00	0.98	***
Career goal innovative work	3.00	2.33	0.00	0.87	***

[1] Cohen's d significance levels: *>.20 (weak effect), **>.50 (medium effect), ***>.80 (strong effect)

The SCCT model places innovation self-efficacy and innovation outcome expectation as key precedent measures to innovative career goals. The results shown in Table 7 indicate that the measures venturing self-efficacy, innovation self-efficacy, innovation interests and career goal innovative work all show significant differences between Starters and Joiners. Starters show very high innovation interests (p-value < .00, Cohen's d = .98) with a mean difference of 0.64. Not surprisingly Starters have a significantly higher venturing self-efficacy than Joiners (p-value < .00, Cohen's d = .89) with a mean difference of 1.01. Innovation self-efficacy (p-value < .00, Cohen's d = .60) and career goal innovative work (p-value < .00, Cohen's d = .87) measures also reveal significant differences between Starters and Joiners. Interestingly, the innovation outcome expectation measure does not show a significant difference between Starters and Joiners (p-value = .07, Cohen's d = .08).

5.0 Discussion

Our findings are consistent with that of Lintl *et al.* We find that Starters are "new seeking", and they report significantly higher innovation and entrepreneurship related self-efficacy. Their self-efficacy is key to the career-decision process. Overall the current study shows that the access to domain specific (learning) experiences and therefore to learning opportunities may be key to sparking the entrepreneurial spirit. For example, the participation in entrepreneurial students clubs appears to make a difference. To encourage more Starters, universities may consider cultivating a healthy and communicative environment with low barriers for students who want to engage in entrepreneurial activities and exchange ideas with fellow students and faculty. The results on innovation measures are also in line with the findings from Lintl *et al*. Finally, the fact that there was no significant difference in the innovation outcome expectation between Starters and Joiners might be explained by the age of the target group of the EMS; this measure was constructed in such a way that could have made it difficult for students to imagine what results will be if they ask many questions in their first job.

Future work could include students from non-engineering majors to learn more about the potential differences between technical and non-technical oriented students. An international comparission could be addded to gain deeper knowledge about how different cultures and educational systems influence students' innovation-related career goals.

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References

Adner, R., & Kapoor, R. (2010). Value creation in innovation ecosystems: how the structure of technological interdependence affects firm performance in new technology generations. *Strategic Management Journal*, *31*(3), 306–333. https://doi.org/10.1002/smj.821

Bandura, A. (1977). Self-efficacy: Toward a Unifying Theory of Behavioral Change. *Psycological Review, 84*(2), 191-215.

Bandura, A. (1986). *Social foundations of thought and action. A social cognitive theory.* Englewood Cliffs, NJ: Prentice Hall.

Bandura, A. (1989). Human agency in social cognitive theory. *American Psychologist, 44*(9), 1175.

Brunhaver, S. R., Sheppard, S., Antonio, A. L., & Barley, S. R. (2015). Early career outcomes of engineering alumni: Exploring their connection to the undergraduate experience. Retrieved from https://searchworks.stanford.edu/view/11367251

Delgado, M., Porter, M. E., & Stern, S. (2010). Clusters and entrepreneurship. *Journal of Economic Geography, 10*(4), 495–518. https://doi.org/10.1093/jeg/lbq010

Drucker, P. F. (2015). *Innovation and Entrepreneurship: Practice and Principles.* Abingdon: Routledge.

Duval-Couetil, N., & Dyrenfurth, M. (2012). Teaching Students to be Innovators: Examining Competencies and Approaches Across Disciplines. *International Journal of Innovation Science, 4*(3), 143-154.

Dyer, J., Gregersen, H., & Christensen, C. (2011). The DNA of Disruptive Innovators *The innovator's DNA: Mastering the five skills of disruptive innovators.* Boston, Massachusetts: Harvard Business Review Press.

Dyer, J., Gregerson, H., & Christensen, C. (2008). Entrepreneur behaviors, opportunity recognition, and the origins of innovative ventures. *Strategic Entrepreneurship Journal, 2*, 317- 338.

Dym, C. L., Agogino, A. M., Eris, O., Frey, D. D., & Leifer, L. J. (2005). Engineering Design Thinking, Teaching, and Learning. *Journal of Engineering Education, 94*(1), 103–120. https://doi.org/10.1002/j.2168-9830.2005.tb00832.x

Eesley, C. (2011). Stanford Innovation Survey Blog. Retrieved from http://stanfordinnovationsurvey.blogspot.de/

Eesley, C., & Miller, W. (2012). Impact: Stanford University's Economic Impact via Innovation and Entrepreneurship. Retrieved from https://stacks.stanford.edu/file/druid:pk969cv9166/Stanford_Alumni_Innovation_Survey_Report_102412_1(1).pdf

Epicenter. (2015). Survey Results: Innovation and Entrepreneurship Communities. Retrieved from http://epicenter.stanford.edu/resource/innovation-entrepreneurship-living-learning- programs.

Epicenter. (2016). How to complete the landscape canvas. Retrieved from http://epicenter.stanford.edu/page/university-innovation-fellows.

Feldman, M. P. (2014). The character of innovative places: entrepreneurial strategy, economic development, and prosperity. *Small Business Economics, 43*(1), 9–20. https://doi.org/10.1007/s11187-014-9574-4

Gilmartin, S., Shartrand, A., Chen, H., Estrada, C., & Sheppard, S. (2014). *U.S.-Based Entrepreneurship Programs for Undergraduate Engineers.* Retrieved from Stanford, CA & Hadley, MA: http://epicenter.stanford.edu/documents/221

Gilmartin, S.K., Chen, H.L., Schar, M.F., Jin, Q., Toye, G., Harris, A., Cao, E., Costache, E., Reithmann, M., & Sheppard, S.D. (2017). Designing a Longitudinal Study of Engineering Students' Innovation and

Engineering Interests and Plans: The Engineering Majors Survey Project. EMS 1.0 and 2.0 Technical Report. Stanford, CA: Stanford University Designing Education Lab.
Hackett, G., & Betz, N. E. (1981). A self-efficacy approach to the career development of women. *Journal of Vocational Behavior, 18*(3), 326-339.
Kanter, R. (1988). When a thousand flowers bloom: Structural, collective, and social conditions for innovation in organizations. *Research in Organizational Behavior, 10*, 169-211.
Lent, R. W., & Brown, S. D. (2006). On conceptualizing and assessing social cognitive constructs in career research: A measurement guide. *Journal of Career Assessment, 14*(1), 12-35.
Lent, R. W., Brown, S. D., & Hackett, G. (1994). Toward a Unifying Social Cognitive Theory of Career and Academic Interest, Choice, and Performance. *Journal of Vocational Behavior, 45*, 79-122.
Lintl, F., Jin, Q., Gilmartin, S., Chen, H., Schar, M., & Sheppard, S. (2015). *Starter or Joiner, Market or Socially-Oriented: Predicting Career Choice among Undergraduate Engineering and Business Students.* Paper presented at the 122 ASEE Annual Conference & Exposition, Seattle, WA. http://epicenter.stanford.edu/documents/741
Lucas, W., Cooper, S., Ward, T., & Cave, F. (2009). Industry placement, authentic experience and the development of venturing and technology self-efficacy. *Technovation, 29*, 732-752.
Osorio, C. (2011). *Design Thinking-based Innovation: How to do it, and how to teach it.* Paper presented at the BALAS Annual Conference, Santiago, Chile. http://www.academia.edu/193343/Design_Thinking-Based_Innovation
PEARS - Pathways of Engineering Alumni Research Survey. (2007). Retrieved from http://pearsurvey.stanford.edu/
Porter, M. E. (1998). Clusters and the New Economics of Competition. *Harvard Business Review, 76*(6), 77–90.
Schar, M., Billington, S., & Sheppard, S. (2014). *Predicting Entrepreneurial Intent Among Entry-Level Engineering Students*. Paper presented at the American Society for Engineering Education (ASEE) Annual Meeting, Indianapolis, IN.
Scott, S., & Bruce, R. (1994). Determinants of innovative behavior: A path model of individual innovation in the workplace. . *The Academy of Management Journal, 37*(3), 580-607.
Sheppard, S., Cao, E., Chaffin, B., Chen, H., Gilmartin, S., Grau, M., . . . Toye, G. (2015). Engineering Majors Survey. Retrieved from http://epicenter.stanford.edu/page/engineering-majors-survey
Sheppard, S., Gilmartin, S., Chen, H. L., Donaldson, K., Lichtenstein, G., Eris, O., . . . Toye, G. (2010). Exploring the Engineering Student Experience: Findings from the Academic Pathways of People Learning Engineering Survey (APPLES) (TR-10-01). Retrieved from http://www.engr.washington.edu/caee/APPLES_report.html
Singh, R., Fouad, N. A., Fitzpatrick, M. E., Liu, J. P., Cappaert, K. J., & Figuereido, C. (2013). Stemming the tide: Predicting women engineers' intentions to leave. *Journal of Vocational Behavior, 83*, 281–294.

Appendix A - Measures Description

EMS Question 20 on Future Career Goals
"How likely is it that you will do each of the following in the first five years after you graduate?" Ranked on a 0 to 4 Likert Scale from "Definitely will not" to "Definitely will"
Items:
Work as an employee for a small business or start-up company (asbus)
Work as an employee for a medium- or largesize business (blbus)
Work as an employee for a nonprofit organization (excluding a school or college/university) (cnon)
Work as an employee for the government, military, or public agency (excluding a school or college/university) (cgov)

Work as a teacher or educational professional in a K-12 school (etch)
Work as a faculty member or educational professional in a college or university (fcoll)
Found or start your own for-profit organization (gsfor)
Found or start your own nonprofit organization (hsnon)

Innovation Self-Efficacy (ISE.5), Cronbach's Alpha = .79
"How confident are you in your ability to do each of the following at this time?" Ranked on a 0 to 4 Likert Scale from "Not confident" to "Extremely confident"
Items:
Generate new ideas by observing the world
Experiment as a way to understand how things work
Actively search for new ideas through experimenting
Build a large network of contacts with whom you can interact to get ideas for new products or services
Connect concepts and ideas that appear, at first glance, to be unconnected

Venturing Self-efficacy
"How confident are you in your ability to do each of the following at this time?" Ranked on a 0 to 4 Likert Scale from "Not confident" to "Extremely confident"
Items
Take the steps needed to place a financial value on a new business venture

Innovation Interest, Cronbach's Alpha = .78
"How much interest do you have in … " Ranked on a 0 to 4 Likert Scale from "Very low interest" to "Very high interest"
Items
Giving an "elevator pitch" or presentation to a panel of judges about a new product or business idea ?
Experimenting in order to find new ideas ?
Developing plans and schedules to implement new ideas ?
Finding resources to bring new ideas to life ?
Conducting basic research on phenomena in order to create new knowledge ?

Working on products, projects, or services that address societal challenges ?
Working on products, projects, or services that have significant financial potential ?

Innovation Outcome Expectations, Cronbachs Alpha = .70
„Imagine the work you will be doing in the first year after you graduate. Estimate what will happen if you “ask a lot of questions” in this work“ Ranked on a 0 to 4 Likert Scale from “Defiantly will not” to “Definitely will”
Items
I will be seen as a troublemaker.
I will earn the respect of my colleagues.
I will be seen as a “star” in this work.
I will hurt my chances for moving ahead.