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Encouraging Technology-Based Ventures: Entrepreneurship Education and Engineering Graduates

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This article examines entrepreneurship courses offered by engineering faculties in Canada. The venturing rate of engineering students, whether the venturing rate increases if students have taken a course in entrepreneurship, and the type of ventures created are also explored. A recent census and an empirical study of two groups of engineering graduates from a Canadian university were utilized. Findings have implications for educators and administrators and for policy-makers interested in encouraging economic growth.

Graduates from university faculties of engineering are perhaps the most promising cohort from which we would expect high-technology start-ups. Apart from their exceptional academic skills, these graduates have an in-depth knowledge of technology in a specific area and have worked on practical projects throughout their degree studies. They may also, on graduation, work for a technology-related company and thus be accumulating the skills, knowledge, and personal readiness (e.g., financial, networking) for launching their own business. In addition, some of these engineering graduates may have taken courses in entrepreneurship during their engineering degree studies. Entrepreneurship education has been touted as valuable in encouraging venturing and with increasing the success of ventures (Gillin and Powe 1994; Gorman and Hanlon 1997; Hood and Young 1993; McMullan and Vesper 1987; Timmons 1999; Wyckham and Wedley 1990; Young 1997). Specifically, in relation to engineers, Blais (1997) cites multiple advantages for providing engineering students with courses in entrepreneurship. These include nurturing a sociological perspective within engineering students including teamwork and joint initiatives, creativity, innovation, and practical applications as well as teaching them the specifics of new venture creation. Entrepreneurship education is also valuable for graduates who pursue a position within a larger corporation (Hood and Young 1993).

Because technology-based start-ups and ventures have considerable payoff at the personal, regional, and national level, it is appropriate to study how they are nurtured. This article looks at what faculties of engineering are doing to encourage students to pursue a career as an entrepreneur. It also explores the venturing rate and type of ventures started by graduates of one faculty of engineering. The research questions posed in this article are:

1. Do faculties of engineering provide entrepreneurship education? What is the breadth and depth of these offerings?
2. Do engineering graduates venture at a rate above the population in general?
3. Is there a difference in venturing rates according to whether graduates have taken an entrepreneurship course during their undergraduate degree?
4. Do engineering graduates start technology-related ventures?

Previous Literature

Surveys of the incidence and type of entrepreneurship courses have been conducted (Blais 1997; Duke 1996; Gartner and Vesper 1994; McMullan and Vesper 1987; Menzies and Gasse 1999; Vesper 1985, 1993; Vesper and Gartner 1997, 1999; Vesper and McMullan, 1988). Vesper and Gartner are the most well known for their surveys of entrepreneurship education worldwide. As would be expected, their surveys show a tremendous growth over the last 20 years in entrepreneurship education at universities. Looking at Canada in particular, a Canadian Academy of Engineering 1996 survey showed 33 (79%) engineering schools in Canada that either offered, or were intending to offer, undergraduate courses on entrepreneurship and closely related subjects (Blais 1997). In their census of entrepreneurship education offered by universities in Canada, Menzies and Gasse (1999) found that 52 (98%) universities offer entrepreneurship education, mostly within their faculties of business, and that undergraduate entrepreneurship courses were offered in only 16 (48%) faculties of engineering (see Table 1). In some universities, engineering students can take entrepreneurship courses offered by the faculty of business, however, unless there is a formalized program, this may not be easy for students to schedule into their course load. Very few entrepreneurship courses are offered to engineering students at the graduate level.

Range of Entrepreneurship Courses

Table 2 shows the types of courses offered in the engineering schools. The norm is to offer one or two courses. These courses are most commonly an introduction to the field of entrepreneurship, with some orientation toward technology start-ups. The second most common type of course deals with business planning and start-up activities. Additional courses are offered on management of a

Table 1 Number of Credit Courses offered in Entrepreneurship by the Engineering Faculty		
University (1998/99 Academic year)	Undergraduate Courses	Graduate Courses
University of Alberta	1	
University of Calgary ^a (degree minor)	5	1
Carleton University	1	
Concordia University	4	
Université Laval	6	
McGill University (degree minor)	6	3
University of New Brunswick	2	
Université du Québec À Chicoutimi	2	
Université du Québec À Hull	2	
Université du Québec en Abitibi	2	
Queen's University	1	
University of Regina	1	
University of Sherbrooke	2	
Simon Fraser University	2	
University of Toronto	4	
University of Waterloo	1	1
University of Western Ontario	1	
a. Collaborative program with the faculty of business.		

start-up or relatively new business and managing an established business. Courses about innovation, creativity, and opportunity identification are the least common. Only a handful of universities (Calgary, Laval, McGill, New Brunswick, and Toronto) offer breadth and depth of entrepreneurship courses. Engineering students at these universities are served well by the range of entrepreneurship courses available and the degree minor that they can obtain in entrepreneurship (Calgary and McGill). However, little is known about the outcomes (e.g., venture starts by graduates) in relation to these courses.

Propensity to Venture

Surveys of entrepreneurship provide information on the availability of entrepreneurship education. However, there is a distinct lack of research into the propensity of university graduates to venture. McMullan and Gillin (1998) found that at Swinburne University in Australia, 87 percent of graduates from the entrepreneurship program started their own business or were intrapreneurs. In this article, intrapreneuring is not included within the definition of venturing. The authors could find no study in the literature that looked at entrepreneurship education and engineering graduates' rate of venturing. However, a few studies looked at graduate propensity to venture and found rates ranging from 5 to 47 percent.

In the United States, Wheeler (1993) found that 47 percent of science graduates ventured, as compared to

Table 2 Types of Courses Offered						
University	Introduction to Entrepreneurship ^a	Innovation Management ^b	Small Business Management/ Human Resources Management ^c	New Venture Creation/ Enterprise Development ^d	Entrepreneurship and Technology ^e	Management ^f
Alberta						X
Calgary	X	X	X	X ^{2g}		
Carleton						X
Concordia						X
Laval	X		X	X		X
McGill	X		X		X ⁴	
New Brunswick					X ⁴	X ²
UQAC				X ²		
UQAH				X ²		
UQAT	X	X				
Queen's	X					
Regina	X					
Sherbrooke	X			X	X	
Simon Fraser		X	X			
Toronto		X	X ²	X		
Waterloo	X					
Western			X			
a. Introduction (sometimes technically oriented) to the field. b. Innovation and opportunity identification. c. Managing a business after start up. d. Business planning and start-up readiness. e. Incorporating technology into the business. f. Managing an established business. g. Superscript number denotes number of courses. No superscript after X denotes one course.						

only 35 percent of business majors. Much lower rates were found in Ireland where only 5 percent of university graduates owned a business within 5 years, and 15 percent by 10 years after graduation (Fleming 1996). Varying rates were reported for those graduates with degrees in entrepreneurship. Kolvereid and Moen (1997) found that entrepreneurship graduates were more likely to venture than graduates with other degrees. Upton, Sexton, and Moore (1995) found that several years after graduation,

40 percent of graduates had started their own firms, 30 percent worked in a family business, and 30 percent worked for a corporation. Charney and Lidecap (2000) found that just over a quarter of entrepreneurship graduates (27.2%) owned a business, compared with 9 percent for graduates from other areas of business. These studies highlight the problem of estimating the number of graduates who start their own business.

National Entrepreneurial Activity Rates

Reynolds, Hay, Bygrave, Camp, and Autio (2000) found that entrepreneurial activity varies considerably between countries. They report that 12.3 percent of 18- to 64-year-olds in Brazil, 12.7 percent of the U.S. population, 7.9 percent of Canadians, 4.7 percent of Germans, 1.3 percent of Japanese, and 1.2 percent of Irish adults were in the process of starting a new business. They believe that national differences are based on opportunity structure in the society, motivation and skill to capitalize on the opportunity, infrastructure that nurtures new ventures, demography of the population including age and gender, education level of the population, and the culture within the country and perceptions toward business ownership. To make comparisons between the venturing rate of engineering graduates and the general population, census data are used which show that 16.2 percent of the Canadian labor force own their own business (Lin, Yates, and Picot 1999). The next sections examine the remaining three research questions regarding whether engineering graduates venture at a rate above the population, whether there is a difference according to receiving entrepreneurship courses during their degree program, and whether engineering graduates start technology-related ventures.

Methodology

In this research, a 15-year cohort of engineering graduates from a major university in Canada was surveyed. Two groups were utilized. The first group had taken one course in entrepreneurship during their undergraduate studies (EG). The response rate was 99 percent for all students who could be contacted (46 percent). The second group included a stratified random sample control group of engineering graduates from the same university, matched according to year of graduation, engineering program, and gender (CG). The response rate for this group was 12.5 percent. (This research is part of a longitudinal study of students who have taken either one or a block of three courses in entrepreneurship. This article reports on only those who took one course.)

Results

A mail questionnaire and questions specific to this article were used to find out the propensity to venture and business characteristics.¹ Analysis required to answer the research questions included frequencies, Chi square, and t-tests.

Demographics and Venturing Rates

The two groups of engineering graduates were well matched according to age (in their 30s: EG 67%, CG 70%; in their 20s: EG 25%, CG 23%), gender (male: EG 88%, CG 86%), and program (chemical: EG 42%, CG 46%; industrial: EG 12%, CG 14%). About a third (34%) of EG respondents were current businessowners, compared with a fifth (20%) of the CG (see Table 3). There is a significant difference between these groups (χ^2 (1, N = 286) = 7.503, p < .05). When examining business ownership over the long term, nearly half of the EG group (48%) was found to have been a businessowner at some time since graduation, which is significantly different from the control group in which only 26 percent had ever owned a business (χ^2 (1, N = 285) = 14.377, p < .05). There was also a significant difference between the groups according to serial entrepreneurship; that is, owning more than one business concurrently or sequentially (χ^2 (1, N = 287) = 3.973, p < .05). The EG graduates were more likely to own more than one business and to have started several business in sequence.

Table 3 Business Ownership Characteristics and Entrepreneurial Expectations				
Characteristics	EG (n=177)		CG (n=110)	
	n	%	n	%
Current businessowner	60	34.1	21	19.1
Owner at some time	85	48.0	28	25.7
Serial entrepreneur	29	16.4	9	8.2
Business ownership prior BASc ^a	13	22.8	3	18.8
= < 2 years after graduation	18	31.6	3	18.8
3–4 years	8	14.0	3	18.8
5–7 years	11	19.3	2	12.5
8–10 years	4	7.0	3	18.8
> 10 years	3	5.3	2	12.5
a. Percentages calculated across current businessowners.				

Time from Graduation to Business Start

An important concept about venturing and university graduates relates to the number of years between graduation and start-up. Results of this study suggest that graduates who have entrepreneurship education tend to venture sooner after graduation. As noted in Table 3, almost a third (32%) of the EG graduates started a business within two years of their BASc graduation, compared with only 19 percent of CG graduates. Prior to graduation, about a fifth of both groups were already businessowners (ES 23%, CG 19%). About a third of both groups (EG 33.7%, CG

31.3%) started their ventures three to seven years from graduation. Overall, the difference in the time to venture appears to be mainly within the first two years from graduation.

Business Characteristics

A third of both groups (EG and CG) had consulting businesses, mostly related to engineering, and about a fifth owned information technology businesses (see Figure 1). Businesses also included manufacturing, services, real estate, financial services, construction, restaurant, and education services. There were no statistically significant differences between the two groups for type of business or any business characteristics. About 80 percent of both groups started their businesses from scratch, with very few purchasing or joining an existing or family business. More than half of the owners in both groups worked full time in their ventures (EG 68%, CG 53%). The size of the businesses, when measured by number of employees and sales revenue, indicated a wide range (see Table 4). There were many small businesses, with almost half the ventures for both groups having four or fewer employees. Of the EG group, 32 percent of businesses had sales less than \$100,000 (CG 38%), but more than a third in each group had sales between \$500,000 to in excess of \$10 million. The majority of businesses were profitable.

Discussion

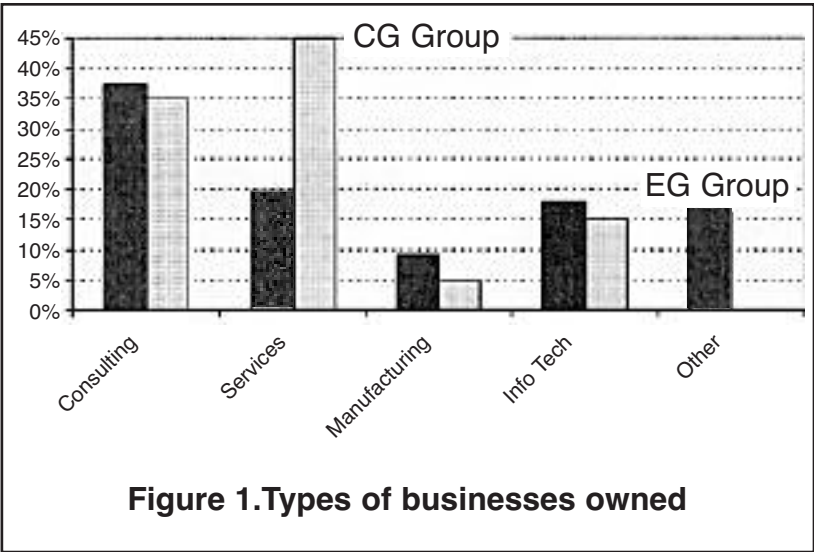
Based on the results presented above, this section addresses the questions posed earlier in this article.

Do faculties of engineering provide entrepreneurship education and what is the breadth and depth of these offerings?

From an examination of the literature, which contains a recent census of education programs in Canada, the researchers found that 16 (48%) faculties of engineering offer mostly one or two, but occasionally more, undergraduate courses in entrepreneurship. These courses are mostly an introduction to entrepreneurship, business planning, start-up readiness courses, or managing an active business. However, the majority of universities offer only one or two courses and do not provide extensive range and depth in entrepreneurship courses. From these findings, the researchers concluded that there is no widespread commitment on the part of faculties of engineering in Canadian universities to offer engineering students formal skills and knowledge for starting their own business. Based on these findings, it would appear that entrepreneurship education should be an integral part of engineering education. The authors suggest there be a shift from electives to required courses in entrepreneurship. There are models of degree minors in entrepreneurship as part of an engineering degree (e.g., University of Calgary); however, these are the exception not the norm. Tradition

dictates much of the coursework in degree programs. Arguments against introducing required entrepreneurship courses may propose that additional course material will dilute the technical material that must be taught or overload students with additional course requirements. Scheduling problems may be used as an excuse or perhaps the lack of available faculty to teach entrepreneurship courses. Faculties of engineering that have one or more entrepreneurship course(s) available for students always have a “senior champion” (Menzies and Gasse

Table 4				
Characteristics of Current Businesses Owned by Graduates				
Business Characteristics	EG (n=60)		CG (n=21)	
	n	%	n	%
Origin: Started from scratch	45	76.6	17	85.0
Purchase	1	1.7	2	10.0
Join a family business	5	8.6	0	0.0
Join an existing firm	5	8.6	1	5.0
Other	2	3.4	0	0.0
Type: Consulting	20	35.1	7	36.8
Services	5	8.8	4	21.1
Real estate	2	3.5	2	10.5
Financial Services	3	5.3	0	0.0
Construction	2	3.5	0	0.0
Restaurant business	1	1.8	2	10.5
Manufacturing	4	7.0	0	0.0
Education services	1	1.8	0	0.0
Information technology	11	19.3	3	15.8
Retail	0	0.0	1	5.3
Other	6	10.5	0	0.0
Commitment: Full time	39	68.4	10	52.6
Part time	18	31.6	9	47.4
Profitability: Profitable	41	74.5	17	88.9
Breakeven	8	14.5	2	11.1
Not profitable	6	11.0	0	0.0
No. Employees: 1–2	21	37.5	8	42.1
3–4	9	16.1	1	5.3
5–6	5	8.9	1	5.3
7–8	5	8.9	1	5.3
9–19	6	10.7	6	31.6
20–30	2	3.6	1	5.3
31–50	1	1.8	0	0.0
>50	7	12.5	1	5.3
Sales: < \$100,000	17	32.1	6	37.5
\$100,001–\$250,000	12	22.6	2	12.5
\$250,001–\$500,000	4	7.5	2	12.5
\$500,001–\$1 million	6	11.3	5	31.3
>\$1 million–\$2.5 million	3	5.7	0	0.0
>\$2.5 million–\$5 million	2	3.8	0	0.0
>\$5 million–\$10 million	3	5.7	1	6.3
>\$10 million	6	11.3	0	0.0



1999) among the faculty. This champion is vital for the initiation and continuance of entrepreneurship programming. However, it is hoped that the findings of this study and future research, regarding the greater venturing rate of students who have taken a course in entrepreneurship, may be influential in creating a culture of change within the faculties of engineering, regarding offering mandatory entrepreneurship courses.

Is there a difference in venturing rates according to whether graduates have taken an entrepreneurship course?

The results in relation to business ownership show statistically significant differences between graduates who have taken a course in entrepreneurship and those who have not. Those who have taken a course in entrepreneurship have a higher tendency to start their own business and to do so more quickly after graduation. Of those who had taken an entrepreneurship course, 34 percent (CG 19%) were current businessowners and 48 percent (CG 26%) had been an entrepreneur at some time since graduation. These findings raise interesting questions to be addressed in future research regarding motivation to start a business. Do students elect to take the course because they feel pulled into entrepreneurship (Amit and Mueller 1994)? Do these graduates then choose a particular career path that will facilitate venturing at some time in the future? For example, when they have acquired the necessary “chunks of venturing knowledge” (Timmons 1999). Clearly the course in entrepreneurship produced effective outcomes. It provided venturing awareness and venture readiness skills and knowledge. Future research should address these questions: Does the course introduce or reinforce a different way of thinking that enables graduates to recognize and act on venture opportunities? Do networks created during, and after the course, facilitate venturing, as has been reported in the literature (Aldrich and Zimmer 1986)? Does the presence

of a mentor who is venturing experienced and technically expert, in the form of the course instructor, contribute to an increased venturing rate? (Mentoring starts during the course but continues through the venture creation and growth stages.) The results indicate that a single course in entrepreneurship is an effective means of increasing the venturing rate of engineering graduates. Further research should focus on the aspects and components of the course that are most effective.

Do engineering graduates venture at a rate above the population in general?

The results show that engineering graduates, in general, have a higher venturing rate than the general population. Nineteen percent of the control group were businessowners; moreover, at some time 26 percent had owned a business. The most recent numbers available from the Canadian Census show that only 16 percent of the Canadian population are self-employed. Given that the survey respondents are still fairly young in terms of career expectancy, it can be assumed that there will be an increased rate of venturing as the cohort ages. Recent research has found that technical training and experience enhanced the likelihood of venturing (Fiet and Samulesson 2000). It may thus be possible to increase the venturing rate of engineering graduates, in general, if entrepreneurship courses were offered as part of a degree in engineering rather than only as an elective.

Do engineering graduates start technology-related ventures?

The results show that engineering graduates start a range of businesses. Most businesses they start are related to engineering (e.g., consulting, information technology, manufacturing). However, some businesses are not what would be generally considered technology-based. Restaurants, landscape gardening, and a tutoring service are among the “low-tech” start-ups. Further research is required into how the businesses started by graduates are related to their engineering degree. This study shows that many engineering graduates create technology-based start-ups, which are leveraged on their engineering skills and knowledge, rather than low-technology ventures. Technology-intensive new ventures have greatly enhanced outcomes if there is extensive use of networking by the lead entrepreneur(s) (Zhao and Aram 1995). One of the major advantages of taking a course in entrepreneurship may be the training in network creation and maintenance and the opportunity to capitalize on existing and new networks. The mentoring role of the course instructor may also be useful for nurturing technology-related ventures. There are many other important variables that determine the type of venture. In subsequent stages of the longitudinal study of engineering graduates, the opportuni-

ty-identification process in relation to business creation will be examined.

Implications for Theory, Practice, and Policy

Findings from this study contribute to the growing literature on whether entrepreneurship can be taught. Results from this study indicate that entrepreneurship education is an effective way to increase the venturing rate of engineering graduates. The study provides results that have quantified the venturing rates for two groups of engineering graduates. Furthermore, it has provided business characteristics and performance data. This research is useful for advancing the debate on the value of entrepreneurship education. These findings show that further research is necessary to advance theories on the importance of push and pull factors, networking, and the cognitive disposition to venture. The study provides a model to critique and replicate in an attempt to build theory about a range of questions relating to venturing.

This research is valuable for educators who are currently teaching entrepreneurship. Knowledge regarding the high venturing rate may have an influence on the scope and content of course material. Knowing that almost a third of graduates may start a business within two years of graduation, indicates that practical application is an important part of course content. Educators and trainers in a range of organizations will find that the venturing rates reported here provide a benchmark for measuring the success rate of their courses. Furthermore, the time frame within which graduates venture and the performance data on businesses allows for comparisons with other cohorts in universities, colleges, and training facilities.

At the policy level, this study shows university administrators that entrepreneurship education is effective in producing alternative career paths for graduates through an increase in self-employment and business ownership. High graduate employment is an important measure of success for most education programs. Thus, these

findings are important for administrators in all educational establishments, and also in a range of disciplines, not just engineering. At the government level, the study indicates that for a small investment in education, regional and national economic growth may be increased. Governments worldwide are seeking to increase the number of business starts and especially high-technology-related ventures. This study indicates that entrepreneurship education is important as engineering graduates can be a major driver of economic growth through their technology-based start-ups.

Conclusions

This article has addressed four research questions. It would appear that engineering graduates are a prime group for starting technology-related businesses at rates above the general population. Among those who elect to take some entrepreneurship education, there are an astonishingly high number of ventures started after graduation (48% businessowner at some time, 34% current businessowner). Further research is required to establish whether it is a natural inclination that leads to the higher venturing rate, or whether raising awareness of entrepreneurship as a viable career and teaching some readiness skills can nurture technology start-ups among engineering undergraduates. What is clear, however, is that so far in Canada, too few faculties of engineering provide entrepreneurship courses for engineering undergraduates. Perhaps it can be argued that students can look elsewhere for this training. Alternatively, students can acquire these skills following graduation, when they have more work experience. There are two arguments against this perspective. First, it is important to include a course in entrepreneurship within an undergraduate program to relay venturing awareness as well as readiness skills and knowledge. Second, as engineering graduates are venturing relatively soon after graduation, it is important to provide venturing readiness skills and knowledge during their undergraduate education.

Endnote

- 1. Contact the authors for a copy of the questionnaire.

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