Introducing Entrepreneurial Education in a Small Traditionally Non-Entrepreneurial Engineering School

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Abstract

Many engineering programs within universities, such as Stanford University, the Massachusetts Institute of Technology, and the University of Maryland, have had great success in creating entrepreneurial programs for their students. These programs have benefited from faculty, staff, and student interest in the entrepreneurial process. But how do you effectively develop entrepreneurial education at a school where such interest, by and large, has not existed before? The University of the Pacific is known for practical undergraduate engineering education and a Co-op program that prepares students for employment after graduation. While this combination is wildly successful and appreciated by students and faculty, it skews education towards preparation for corporate functional positions and not entrepreneurial opportunities. This paper will discuss the introduction of entrepreneurial education to engineering students with little or no prior exposure to it beforehand. Specifically, the paper will discuss the evolution of a course meant to introduce students to entrepreneurial activities, as well as discuss how engineering faculty at the University of the Pacific leveraged external resources, such as business school faculty, start-up companies, and angel and venture investors, to create an environment conducive to entrepreneurial education.

Introduction

Entrepreneurial education for engineers is an increasingly common subject on American university campuses. Many universities have developed formalized programs for introducing engineers to entrepreneurial activities, but anecdotal observations reveal that many of these efforts are taking place at the graduate level. In northern California alone, Stanford University, University of California Berkeley and University of California Davis have formal programs that link engineering and other technical graduate students with business school students in an effort to commercialize research projects, often culminating with a business plan competition. Introducing entrepreneurship to graduate students has its benefits. First, student experience and sophistication can affect the willingness to participate in entrepreneurship courses. Secondly, graduate curriculum guidelines are less impacted by accreditation boards, specifically the Accreditation Board for Engineering and Technology (ABET). Third, there is some general confusion among faculty and administrative personnel regarding the concept of entrepreneurship and the pedagogy surrounding it. At the University of the Pacific School of Engineering and Computer Science, which does not have a graduate program, each of these problems was encountered upon initiating a course that introduces upper-division undergraduate engineering students to entrepreneurship.

The University of the Pacific is a small private university in California equidistant from the Silicon Valley and Sacramento. Despite close proximity to entrepreneurial clusters, the area directly adjacent to the University of the Pacific is not entrepreneurially focused in a relative sense. Where there is a strong industrial focus on technology in surrounding regions, the underlying economic base surrounding the Pacific campus is primarily agricultural and low-tech manufacturing. As such, there are few entrepreneurial endeavors to use as engineering case studies. However, the University of the Pacific has put forth an effort to investigate its role in fostering entrepreneurial activity with respect to capitalizing on discoveries generated on campus as well as basic economic development in the surrounding area.

One of the hallmarks of the School of Engineering and Computer Science at the University of the Pacific is its Co-operative Education Program (Co-op). Prior to graduation, each engineering student at Pacific must complete a total of 12 months of full time engineering employment. Generally speaking, the Co-op is complete in two modules whereby the student may choose to work for two different employers or the same one for both modules. The Co-op program ensures that each graduating engineering student has one year of practical and applicable work experience.

Despite the lack of high-technology focus, many nearby companies employ a high proportion of engineers. So, while all Pacific engineering students graduate with experience in engineering, they are oftentimes exposed to engineering careers that are not entrepreneurially focused. The coursework many students site as being apropos to their Co-op positions are traditional engineering courses focused on mechanics and discipline-specific design courses.

The University of the Pacific also recently underwent an ABET review in order for specific programs to gain or retain their accreditation. As part of the review, the ABET review team evaluated whether or not the program meets certain criteria. The criteria are generally focused on programmatic educational objectives and outcomes and assessment of those objectives and outcomes. The ABET guidelines do not specifically address entrepreneurship, but when developing an engineering course that can be applied towards graduation must be cognizant of ABET consideration.

Constraints on developing a course on entrepreneurship for engineers

Because of the interest in entrepreneurship on a university and faculty level, a course on engineering entrepreneurship was investigated for the spring 2006 semester. The course would begin as an advanced topics course within the Engineering Management program, but it would be constrained by multiple factors. First, the course would be offered through the Engineering Management program and would become a core requirement for Engineering Management students. As a core course, the planned engineering entrepreneur course would have to satisfy ABET standards for engineering education and fulfill the mission of the program. In other words, the course must have design and synthesis components and not simply be a business course for engineers without a scientific and mathematical basis. Because the program required of Engineering Management students to graduate are highly populated with courses offered through the School of Business, any additional required courses for Engineering Management

students must be engineering courses. Conversely, since many Engineering Management students (the group that would most likely populate the earliest offerings of the course) have completed many business courses, very little basic business material would have to be presented.

Secondly, the course, while core to Engineering Management students, would be open for all engineering students. This constraint made it difficult to require all but basic prerequisites for the planned course. Third, feedback on the proposed course content would be solicited from faculty. Because the University of the Pacific is a relatively small University, a conscious effort is made to not duplicate faculty efforts in multiple classes. As such, it is important to avoid having redundant courses or having materials repeated in multiple classes.

One last constraint was added as the engineering entrepreneurship course was being devised. Due to the University's close relationship with industry through the Co-op program, many upper-division courses receive feedback from industry leaders. The proposed class, in keeping with this tradition, would solicit feedback from people with entrepreneurial backgrounds. Because the surrounding region does not have a critical mass of engineering- or technology-based entrepreneurship, those relationships would have to be fostered from the ground-up from surrounding regions.

Advanced topics in engineering management: introducing students to entrepreneurship

While introducing engineering students to entrepreneurship was the primary focus of the class, developing the course as an engineering course was key. Therefore, the tenor of the course followed many other industrial engineering or engineering courses in that it focused on systems analysis or resource allocation. Peter Drucker was fond of quoting the nineteenth-century economist J. B. Say, stating "The entrepreneur shifts economic resources out of an area of lower and into an area of higher productivity and greater yield."[1] As such, the course was not presented so much as a course on how to start a business, as entrepreneurship is often perceived, but rather as a course about shifting resources from areas of low to high yield. This paradigm also resonated with students that had Co-op experience with low-tech companies that were always looking for tools and methods for continually improving their operations.

University faculty in the School of Engineering and Computer Science and School of Business were solicited for feedback regarding a course on engineering entrepreneurship. While a product development course was currently being taught within the School of Business, such a subject was lacking within the School of Engineering and Computer Science. Additionally, the course being offered at the School of Business was largely conceptual and without an engineering design component. Other courses peripheral to entrepreneurship, such as finance, marketing, and organizational behavior were currently being taught elsewhere in the university, so the proposed course in engineering entrepreneurship would not cover those subjects in depth. The outcome from surveying courses throughout the University was that the best approach to designing a course on engineering entrepreneurship would be to focus the course on new product development, particularly in terms of highlighting the allocation of necessary resources for designing, testing, and prototyping new technology-based products.

Next, feedback from industry professionals was solicited. Mostly, technology entrepreneurs, venture capitalists, and angel investors from adjacent regions were queried. These interviews revealed that most professionals felt that a university course on engineering entrepreneurship should focus on the real world problems associated with building companies or allocating resources from low to high yield uses. Specifically, students should be taught that in most entrepreneurial environments, there is rarely, if ever, enough of the requisite resources present to pursue business opportunities as a company would choose to have. This conundrum is echoed by the Harvard Business Schools definition of entrepreneurship, which is "the pursuit of opportunity beyond the resources that you currently control."[2] This advice was much more practical in that the course should not focus on teaching students to develop specific skills, but should rather prepare students for allocating insufficient resources and develop skills for using more readily available substitute resources.

Lastly, courses on engineering entrepreneurship offered at other universities were benchmarked. These courses ranged from a course on teaching entrepreneurship to high school science and math teachers[3], senior engineering students[4,5], and international engineering students[6,7]. This investigation revealed that the designs for engineering entrepreneurship courses are quite varied and there appears to be no standardized curriculum for such courses.

Taking all of this input into consideration, the final course description is as follows:

Using interactive lectures, participatory classroom exercises and case studies, this course provides an introduction to managing and leading product development in complex technical organizations. Students will learn about what it takes to build sustainable new products or create entirely new sources of revenue within an existing company. The class will include topics at the forefront of managing innovative companies, including strategic, tactical and operational planning; innovation and technological cycles; intellectual property management, the elements of entrepreneurship and intrapreneurship, new product development, and human relations topics for technical managers.

Specific topics that focused on moving resources from low to high yield uses covered in the course include but are not limited to:

- Business models
- Financing new products (including the venture capital food chain)
- Defining value the proposition of new products
- Defining the value chain of a product
- Market segmentation
- Competitive strategy
- Prototyping
- Product architecture
- Organizational development

The course was very well received in the spring 2006 semester, attracting eight students, which is considered well populated by University of the Pacific standards for a new course. In the spring of 2007, the course enrolled 12 students.

Next steps: integrating engineering entrepreneurship with other University-wide efforts to promote entrepreneurship

The next step for the Advanced Topics in Engineering Management course is to integrate it and its students into the larger University-wide effort to promote entrepreneurship in the surrounding region. The University has established a collaborative team for investigating business innovation and entrepreneurship initiatives for fostering business creation in the region surrounding the University. Currently, the team is focusing on creating programs such an Innovation and Entrepreneurship Workshop that will demonstrate how to start a business and write a business plan, as well as establishing a business incubator on campus. The workshop will involve faculty from across the University, such as those in business, law, and engineering. Longer term, the University will sponsor a business plan competition where student teams will be encouraged to compete. Currently, faculty members are working to form a student entrepreneurship club.

For engineering students, the long-term plan is that they will take the Advanced Topics in Engineering Management course that will satisfy needs within their respective engineering curricula and get exposed to entrepreneurship. For those students interested in pursuing entrepreneurial endeavors, they will join the entrepreneurial club to find like-minded teammates or form a team on their own. For additional entrepreneurial education, they can choose to enroll in the multidisciplinary Innovation and Entrepreneurship Workshop. Finally, engineering students can write business plans and enter them in the proposed business plan competition on the Pacific campus or in a competition elsewhere. For students seriously interested in entrepreneurship and expecting to learn about entrepreneurship as part of their university studies, this plan will provide a comprehensive education experience while fitting into their existing engineering curriculum and satisfying ABET requirements.

Conclusions

The University of the Pacific is located in a region that lacks, by and large, a critical mass of technology and engineering entrepreneurial activity. Pacific students, therefore, are not exposed to entrepreneurial endeavors like their counterparts at other universities that are located in more entrepreneurially inclined locations. Pacific students, however, are exposed to local low-technology yet engineering-dependent companies through the School of Engineering and Computer Science's Co-op program. With the University preparing to be a catalyst for entrepreneurial activities, a course aimed at introducing engineering students to entrepreneurship was devised. In order to satisfy programmatic ABET requirements as well as leverage student Co-op experience, the Advanced Topics in Engineering Management course was devised to present entrepreneurship as the allocation of resources from low yield activities to high yield activities, as opposed to a course about starting a business.

While it is too soon to clearly state whether or not the Advanced Topics in Engineering Management course is a success, the process for developing the course has revealed many insights:

- Despite Co-op experience in relatively low-tech industries and a lack of exposure to technology start-up companies, engineering students are interested in entrepreneurship as long as it is framed in a context in which they can readily identify.

- Student Co-op experience, even if not attained in low-tech or non-entrepreneurial companies, can quickly translate to entrepreneurship education because they have experience working with corporate resources.
- Entrepreneurship need not be presented solely as a subject regarding creating businesses. Entrepreneurship can be taught from an engineering perspective of resource allocation, and thus fulfill ABET standards.
- There is no dominant design for engineering entrepreneurship courses. Most courses seem to reflect the interest of students and/or the expertise of the faculty providing the courses.
- For small universities, it is important to solicit feedback from multiple professors and industrial partners. If engineering entrepreneurship is going to be taught from the perspective of intelligent resource allocation, then the course itself should not present material that is redundantly presented in other courses.
- If entrepreneurial activity is not present in adequate quantities adjacent to campus, efforts must be made to identify entrepreneurs and new venture financiers and bring them to campus. The Advanced Topics in Engineering Management course has leveraged several entrepreneurs, venture capitalists, and angel investors for curriculum feedback and case studies from regions adjacent to the region served by the University of the Pacific with great success.

Engineering entrepreneurship can be taught at universities that are not in highly populated high-technology clusters or where students are not commonly exposed to entrepreneurial behavior. However, to do so, faculty must also behave like entrepreneurs and use the resources available to them wisely. This may include molding the class to accommodate student experience, accreditation standards, and distal resources.

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