An Approach to Building a Graduate-level Engineering and Business collaborative entrepreneurial curriculum

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Abstract

Technology-based entrepreneurship, regardless of whether it takes place within a large organization or in a startup, requires a mixture of technological and business skills. Our aim in developing a joint graduate-level entrepreneurial curriculum between engineering and business is to enhance the blended strengths of the two parties, not turn each into the other. Building the bridge between the two disciplines is the goal, not creating an engineering school within the business school or vice versa.

At the Zell Lurie Institute for Entrepreneurial Studies at the University of _______, we believe it is valuable to think of the continuum of new venture formation and growth as a series of development phases.

- Phase I: Discovery – identifying opportunities and shaping them into business concepts;
- Phase II: Feasibility analysis and assessment;
- Phase III: Creating an actionable business plan;
- Phase IV: Launching the business;
- Phase V: Growing the business;
- Phase VI: Exiting your business -- from succession planning to IPOs.

Our current emphasis in the joint curriculum development is to focus on the early phases, where the complementary skills of both the engineers and the business students are crucial. In Phase I, for example, opportunity identification takes two forms: 1. Finding an optimal market opportunity for a given technology and 2. Identifying an emerging market opportunity and determining what technology may be necessary to exploit it. Two new courses have been created and taught to focus on each of these issues: Driving the Innovation Process, and Entrepreneurial Business Fundamentals for Scientists and Engineers. These courses complement previously existing entrepreneurial courses from the other Phases.

Finding an optimal opportunity for an existing technology requires both a fundamental understanding of the technology benefits and an analysis of the market needs to which these benefits could apply. Since both engineering and business skills are necessary, the Innovation course was developed to allow graduate engineering and business students to learn and work together. On the other hand, business students are well-steeped in market opportunity identification instruction in their standard curriculum, while engineers are not. We therefore created a course that would teach the engineers alone the fundamentals of business (marketing, strategy, finance, and innovation) in the context of identifying market opportunities. Since this course immerses the engineering students in the language and thought-processes of business, it serves as a prerequisite for later-stage joint-enrollment courses. Existing entrepreneurial programs were also modified to give students a parallel “lab” experience to complement these courses.
This paper describes the goals, approach, and lessons learned from developing and implementing this joint curriculum at The University of _________.

**Guiding Philosophy**

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We believe it is valuable to think of the continuum of new venture formation and growth as a series of development phases.

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The first three of these Phases, along with product development, are shown as a series of divergent and convergent thinking steps in Figure 1. Most entrepreneurial curriculum begin with convergent thinking Phase III—a business plan writing course. The message to students is that all their ideas are worthy of converting into detailed operating documents. They are not. These ideas must be screened and assessed. The entrepreneur’s time, after all, is the most precious resource of all. There is no sense wasting it on an idea that has no chance of being economically successful. The good news is that there is increasing attention being paid to Phase II of this continuum—determining the feasibility of the business. More and more institutions are beginning to look at teaching methodologies to assess the feasibility of a proposed new business.
Phase I-- identifying opportunities and shaping them into business concepts-- continues to be significantly ignored. While the activities of this Phase are certainly non-quantitative, they are neither magic nor purely intuitive. There is a structure to the methodology, but it takes a breadth of technology and business skills. Our current emphasis in the joint curriculum development is to focus on this early phase, where the complimentary skills of both the engineers and the business students are crucial. In Phase I, opportunity identification can take two forms: 1. Finding an optimal market opportunity for a given technology and 2. Identifying an emerging market opportunity and determining what technology may be necessary to exploit it. Two new courses have been created and taught at the University of ________ to focus on each of these issues. These courses are: Driving the Innovation Process, and Entrepreneurial Business Fundamentals for Scientists and Engineers. This paper describes the goals, approach, and lessons learned from developing and implementing this joint curriculum at The University of ________.

Either finding an optimal market opportunity for a new discovery or determining what future technological discovery could realize an identified emerging market opportunity are two sides of the same opportunity-identification coin. Whether starting with a technology and looking for a yet-to-be-determined market opportunity, or starting from a known market opportunity and driving down to a yet-to-be-discovered technology, these two complimentary processes embody the “fuzzy front end” of an innovation methodology. Clearly “innovation” is the buzzword of this decade. Why is it so important to corporations? In a presentation at Stanford, Geoffrey Moore summed it up:

“We are in a capitalist market. We are in a competitively driven market. And the effect of competition-driven markets is over time to commoditize whatever differentiation a company has and thereby diminish its ability to win customers and win capital and to win sales at attractive margins to create attractive returns. So the only way to respond to that is to continually come up with new differentiation and to do that you have to innovate.”

The message is that companies must continually innovate to come up with new processes and new products that will allow them to stay differentially advantaged in the market and thereby avoid the increased competition and diminishing returns that come with that completion. Since the result of innovation is at the heart of a company’s ability to create future profits, it should not at all be surprising that from either the perspective of an investor or a corporate executive, innovation is a top concern.

But what IS innovation. Part of the difficulty with the proliferation of the use of the word “innovation” is that it is now being used as pseudonyms for creativity or virtually any change. For our purposes we will use the definition often espoused by Dr. Geoffrey Nicholson, retired VP of 3M and product champion of the PostIt Notes. Dr. Nicholson states that:

“Research is the transformation of money into knowledge. Innovation is the transformation of knowledge into money.”
“Innovation” is not what innovators do, rather it is what customers and clients adopt. An innovation is therefore not something that you can self-assign, but is determined by the market. Innovation is therefore a methodology, a methodology that provides a means of transforming knowledge into value that is recognized by individuals of a community or society.

Given that innovation is so important to companies, one would have thought that they would have perfected the methodology by now. So how successful is innovation today? Not very. Empirical data suggests that the all-industry innovation initiative success rate is a mere 4.5%.

Why is it so difficult to produce a successful innovation? After all, essentially all that is required is to develop sustainably differentiable products that satisfy unmet market needs. But to accomplish that, you need a deep understanding of the science that underlies this new product—deeply understanding its core benefits. On top of that you then need to wrap a product around the technology that conjoins its core technology benefits with your understanding of the core needs of a market segment; often before this “market” exists. And to do this you need to follow a development process that appears, due to its stochastic and non-linear nature, to be purely random—or worse—it appears like “magic” or the inherent “genius” of some specially gifted innovators.

Okay, so creating the future is hard. None of us have experience there. Not the innovators, not the customers. And none of us spend much time working there. We are busy solving the problems of today as opposed to identifying the opportunities of tomorrow. As John Naisbitt says, “Problem solvers are still worrying about the fruits that have already fallen, while opportunity seekers look for the new ones that are ripe for the picking.”

Creating New Courses

So how can we improve this outcome? First we have to break the concept that innovations are created by “magic” by those who “get it.” Yes, sometimes lightening strikes. Sometimes an idea will just pop into someone’s head and everything thereafter just clicks on the way to making this concept a commercial success. But the statistics show that this is not very often. Not nearly often enough to fuel an innovation economy or knowledge economy, let alone consistently fuel any company’s future growth. We need a way to create lightening, to create the fire of innovation. What is needed is to transform this one-off, ad hoc method into a teachable, learnable process; a process for negotiating the “fuzzy front end” the innovation process. There is ample instruction for how to complete a business plan or how to grow a business. Increasingly there is information on how to assess a business’ potential. These are all important. Once the spark is formed, managing and growing the flame of a new endeavor is certainly crucial. But we simply cannot wait around for lightening to strike to generate the sparks of new businesses. We need to learn to create fire. Creating that fire takes multi-disciplinary skills and increased communication between the people in which these skills are embodied. The courses developed at the University of _________ take the steps necessary to show students how to create those entrepreneurial fires that can then be nurtured into significant businesses. Starting from either a new technology (Driving the Innovation Process) or identifying a market opportunity that could be transformed by a new technological discovery (Entrepreneurial Business Fundamentals for Engineers and Scientists) each course provides students with structure and experience in linking science and business. To be sure this is no paint-by-numbers deterministic process. It is highly
stochastic and highly iterative. But it is a process nonetheless. One that can be articulated, taught, and effectively implemented. Perhaps even more importantly, the courses teach students how to exchange ideas in teams with diverse backgrounds and perspectives.

_Driving the Innovation Process_ is an elective course for graduate engineering and business students. This course is a technology-to-market course. The course is designed to provide students with the understanding, skills, and tools necessary to complete the first phase of creating a new technology-based innovation: crafting a detailed framework for a business from an innovation source. Finding an optimal opportunity for an existing technology requires both a fundamental understanding of the technology benefits and an analysis of the market needs to which these benefits could apply. Since both engineering and business skills are necessary, the _Driving the Innovation Process_ course was developed to allow graduate engineering and business students to learn and work together.

On the other hand, business students are knowledgeable of market opportunity identification concepts from their standard curriculum, while engineers are not. We therefore created a course that would teach the engineers alone the fundamentals of business (marketing, strategy, finance, and innovation) in the context of identifying market opportunities. Since this course immerses the engineering students in the language and thought-processes of business, it also serves as a prerequisite for later-stage joint-enrollment courses. These courses, in the later Phases of business development continuum, include business assessment and business plan development.

**Modifying existing experiential entrepreneurial programs**

The creation of these two new courses and their integration with the existing courses (product design, business assessment, and business plan writing) gives us a set of courses that cover the continuum of product design and new business development. While each of these individual courses incorporates hands-on projects, we wanted to extend the students’ experiential learnings though additional “lab-work.” In the business school, such “labs” take the form of non-credit action-based learning programs. We were particularly interested in the “up-stream” expansion into Phase I of the new business formation and growth continuum of two specific programs that were already offered by the entrepreneurial institute. The two specific programs that were expanded to cover Phase I of the new business development continuum were the Institute’s “Dare-to-Dream” grant program and the University’s business plan competition. The goals of modifying these programs were two-fold: 1. lower the barrier for entry for non-business students, and 2. encourage the participation of mixed-discipline teams.

Each of these existing programs was changed by making it multi-staged. The Dare-to-Dream program, for example, was a grant program that students were awarded monies to incent them to write business plans on promising ideas. That program was changed into a multi-step process as illustrated in Figure 2. Step one is now to design the business, by identifying the core elements of the business model by answering the “What,” “Who,” “Why,” and “How” questions. What is precisely is the business’ product offering? What makes this offering differentiated from other offerings? Who specifically are the business’ target customers? Why will they choose your offering (i.e. how do you create value for your customers)? Finally, how does your company
make money or sustain itself? The second stage of this program is to complete a business feasibility study and the final stage is to create a business plan.

![Figure 2. Stage-gate process for business plan development](image)

Each stage has its own monetary rewards that are distributed regardless of the outcome. If a business proves to be infeasible, for example, as long as the student team did a thorough analysis on the project, the grant monies are still awarded. Each stage of the program has its own training sessions that the students are strongly encouraged to attend. The training sessions are essentially super-condensed versions of the courses associated with the related phases of the business development continuum.

The business plan competition was also significantly altered. Historically, submission to the university’s plan competition was a full business plan. This is a huge barrier to entry for a non-business student team. The new approach was to make the competition a tournament with a low barrier to entry for the first round. The first-round presentation is now a three-minute “business hypothesis” pitch (covering the four core elements of the business model). The second round deliverable is a seven-minute summary of the team’s feasibility study. The semi-final and final presentations are on the full business plan. To incorporate these changes and infuse the necessary training sessions into the process, the business plan completion went from essentially a one-day affair to a process that covers the better part of several months. In addition, students are encouraged to “re-team” as the tournament progresses, to encourage the formation of multidisciplinary teams. Finally, a special award was created and presented to the best team that is made up of students from both the business school and the college of engineering. The changes have been wildly accepted by the students. Participation went from 15 teams the year before the change to 40 student teams the year the change was implemented.

In addition, a new program offering was created especially designed to nurture the formation of cross-unit student teams. This program is the entrepreneurial institute’s “Mingle-and-Match” events. These events are somewhat informal with an “open mic” portion where any student that has a business or product concept can take a few minutes to describe it and articulate the kind of team members she or he is looking for. These students can then chat during the casual mixer portion of the meeting, where food and refreshments are offered. Since its inception, this program has been well-attended by students from all across campus.
Outcomes and Learnings

While each specific course in the entrepreneurial curriculum has two over-arching objectives (knowledge enhancement and skills development), the overall goal of the curriculum is also twofold. First and foremost, the students learn to work together across disciplines. The second goal is to help forward the development of potential new businesses. Each group of students (business and engineering) has a tendency to discount the value of the other in creating new businesses. We’ve heard over and over from engineering students how they have a “cool idea” based on a technology they’ve just developed and that if they could just have a few hours of a business student’s time to turn it into a business they’d be set for life. On the other hand, business students often view the science as a “plug-in” to their concept. It is not unusual for business students to approach us with a “complete” business plan hoping we can help them locate a specific technology that must certainly be “lying around” somewhere, that needs to be plugged into their product concept to make it work—like a cold-fusion based, sugar-cube sized mega-watt producing power source! Respecting the knowledge and skills that the other party brings to the table is important. It is also crucial to recognize that it is a diverse team that will be successful, one made up of members that have these diverse skills. At the same time, having people on your team that have these skills is not helpful if there is understanding of how to communicate across these knowledge silos. Learning each other’s language and thought processes is therefore exceedingly important. Building the bridge between the two disciplines is the primary goal of the entrepreneurial curriculum between engineering and business--enhancing the blended strengths of the two parties, not turning each into the other.

Another, more subtle, learning that comes from the combined courses (Driving the Innovation Process; Entrepreneurial Business Fundamentals for Engineers and Scientist) is the understanding that where you end up is the important thing, not where you start. Part of the endless debate in the formation of new technology-based businesses is whether one should start with the marketing side (so-called “market pull”) or the technology (so-called “technology-push”). In these two courses we teach that it simply does not matter. It is like walking; it simply does not matter which foot you begin with—right or left—the important thing is which foot you move next (the opposite one). It is when you move the same foot over and over without moving the other (left-left-left or right-right-right versus left-right, left-right…) that you get in trouble. Similarly if you start with the technology, you need to move to the market side next and vice versa. So-called “technology-push” companies get in trouble when they try to walk technology-technology-technology. It is a balance of market and technology knowledge that leads to successful technology-based businesses.

The second goal of our curricula is to assist with moving a company or a company-in-the-making forward. The projects in the courses provide the vehicle for skill development. It takes just a little more effort to make these project’s “real” versus hypothetical. Whether we work with the graduate student’s own research, research from the technology transfer office, or business opportunities in emerging spaces (energy-water nexus, for example) we strive to forward something real. The reality is, of course, that not all technologies provide the kernel for great businesses nor can every market opportunity be enabled by a yet undiscovered technology. This is an important part of the students’ learning. Sometimes things just do not work. The best
thing an entrepreneur can do is to identify these early. Teams are rewarded for the process they follow to determine the answer and not on the viability of the final outcome.

The courses and concepts have been generally very well-received by students. They truly enjoy working in mixed teams with engineers and business students. When mixed teams are involved, ample time for team development must be built into the course. Tossing students together simply does not make the communications issues go away. In-class exercises that force them to interact have proven to be beneficial.

The biggest success thus far from the joint curricula has been the breaking down of silos between students across the two colleges. The University’s business plan competition now has many entries driven by teams made up of business and engineering students, while this was quite rare five years ago. Participation in both the business plan competition and the Dare-to-Dream program by non-business school students has surged from nearly zero to near 30% of the total students involved in each program.

The biggest challenge with the development of the curriculum has been communicating to would-be entrepreneurs that they need to do something between their invention and their business plan. The popular press constantly reinforces the myth of the “shower idea” to “riches” phenomena. There are lots of steps in between that all successful businesses follow. Sometimes a business will pass through these intermediate steps very quickly, but they still pass through them.

The entrepreneurial programs and courses are now well integrated. The entrepreneurial program changes have aided the new courses as well as been helped by them. The knowledge the students gain in the courses certainly help them perform better in the programs. Contrarily, student’s participation in the programs often sparks their interest to “learn more” and enroll in the classes. Together the courses and programs give the feel for a consistent and contiguous curriculum in entrepreneurship. Although we now have a full spectrum of courses and programs, we understand that students’ interests may be predominately in one or more aspects of the continuum. This is why the curriculum and programs, while being complete across the entire continuum, are offered as a “smorgasbord” from which students can freely pick and choose.

While not without its challenges, such as dealing with multiple curriculum committees and multiple college “norms,” we have thoroughly enjoyed our work in creating this joint curriculum. Breaking down historic silos is challenging and rewarding work.

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i Moore, Geoffrey, Presentation at Stanford Technology Ventures Program, Palo Alto, CA, April 6, 2005.
ii Accenture Survey of CEOs placed innovation in the top 5 concerns.
iv Naisbitt, Mind Set! c 2006