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Discovery to Market: Preparing Faculty and Graduate Students for Technology Commercialization and Entrepreneurship

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Abstract

The desire to move new discoveries from the laboratory to society combined with the evolution of university priorities in funding of operating expenses and research are leading to what Etzkowitz et al. (2000) dubbed the "entrepreneurial university." This development is changing expectations placed on PhD students and faculty, particularly in STEM disciplines, who are increasingly expected to have the mindset, knowledge, and skills necessary to translate their knowledge into technology commercialization activities. This paper describes a full-semester, three-credit course developed at Purdue University called *Life of a Faculty Entrepreneur: Discovery, Development and Translation*, which is designed to respond to these trends and prepare PhD students and faculty for contemporary jobs in both academia and industry. The curriculum introduces participants to the intellectual, financial, and management processes involved in technology commercialization, focusing primarily on university-initiated, early-stage activities. Our goal is to contribute to the scholarship that will better prepare faculty and students to actively and more efficiently engage in technology commercialization activities.

Introduction

Higher education is in a period of innovation and significant transformation. The rising cost of education, a changing global economy, and new learning technologies are increasingly putting teaching and learning missions under scrutiny. At the same time, declining levels of state support and changes in federal funding for both education and research are motivating institutions to seek new ways of generating revenue. Agencies such as NIH and NSF, long considered the "lifeblood of university research" have enabled a system that is considered by some to be at the foundation of U.S. innovation and its leadership role in the world when it comes to technology (Morello, 2013).

This has led to recognition by higher education of what has been dubbed the "entrepreneurial university" (Etzkowitz, Webster, Gebhardt, & Terra, 2000). Research universities are increasingly encouraging faculty entrepreneurs to translate their knowledge into patents, capital and work, with the expectation that this can generate financial revenue to supplement research support, while contributing to economic development and job creation (Duderstadt, 2001). Universities have become more open to entrepreneurial activities on behalf of faculty for other reasons as well, including a belief that outside business activities can enhance a professor's teaching and research; financial incentives encourage faculty to turn fundamental discoveries into technology with commercial potential; and it serves as a means to attract and retain qualified faculty (Biancamano, 2002).

These economic and higher education trends are changing the job prospects for PhD students as well. Many students entering STEM doctoral programs intend to work in academia yet approximately 50% or more end up employed in business, government, and nonprofit sectors (Amsen, 2011; Sauermann & Roach, 2012; Turk-Bicakci, Berger, & Haxton, 2014). Employers hiring PhDs report they expect doctoral programs to train well-rounded disciplinary experts able to generate “real-world” value from knowledge and research (Etzkowitz et al., 2000; Wendler et al., 2010). This requires professional skills that are often not included as part of a PhD dissertation. Entrepreneurial experience (Creed, Suuberg, & Crawford, 2002), leadership skills (Nerad et al., 2009), the ability to adapt to and manage shifting goals (McCook, 2011), and experience collaborating with individuals outside their disciplines could enhance contributions of newly graduated scientists and engineers (Etzkowitz et al., 2000; Gilbert, Balatti, Turner, & Whitehouse, 2004; Gilbert, Balatti, Turner, & Whitehouse, 2004; Taylor, 2011). Focus groups conducted with PhD students in STEM fields found that there is wide variability in perceptions of career preparedness and this is highly dependent on their PhD advisor, and/or the culture and norms of their labs or academic departments (Wheadon & Duval-Couetil, 2014).

To achieve their entrepreneurial goals, institutions invest in entrepreneurship centers, technology transfer offices, incubators, accelerators, mentoring programs, competitions and early-stage venture funds, that lie within or outside the walls or academic boundaries of the university (Boh, De-Haan, & Strom, 2012). Access to entrepreneurship education has grown significantly over the past decade, making it a fast-growing curricular area (Morris, Kuratko, & Cornwall, 2013). Once offered almost exclusively to business students, today entrepreeurship courses are available to students in many academic disciplines. At the undergraduate level, these programs are often in the form or minor or certificate programs (Morris et al., 2013; Shartrand, Weilerstein, Besterfield-Sacre, & Golding, 2010) and take many forms including cross-campus programs which leverage multidisciplinary collaboration, to efforts specifically targeting engineering and STEM students and social or non-profit ventures.

At the graduate level, entrepreneurship courses open to non business students typically emphasize technology transfer and pair scientific teams with MBA students to develop commercialization plans for specific technologies. A long-established example is Georgia Tech’s Technological Innovation: Generating Economic Results (TI:GER) Program, which creates teams of two MBA students and two law students who focus on the commercialization of a PhD student’s research (Thursby, Fuller, & Thursby, 2009). Another example is Ohio State University’s Technology Entrepreneurship and Commercialization (TEC) Institute, which is described as a Proof of Concept Center that provides coursework and consulting services to triage early stage technologies and develop commercialization strategies. Other education models include graduate certificates in technology commercialization for PhD students in science, engineering, and business, which require the completion of a sequence of several courses to be completed in addition to doctoral program requirements.

Federal funding agencies have developed programming to increase the commercial impact of their considerable investments in fundamental research. This is being incentivized through programs such as NSF Innovation Corps (I-Corps) and NIH REACH, which engage faculty scientists, graduate students, and business experts to accelerate the translation of early-stage technology ("NIH selects awardees to help speed development of health technologies," 2015; "NSF I-Corps Celebrates First Year Bridging University Researchers with Entrepreneurs," 2012). These programs are designed to address what is commonly termed the “valley of death,” or the divide between a basic research discovery and a technology or product with commercial potential. They do so by awarding funding to selected teams that is used to evaluate a technology's feasibility and market potential. In the case of I-Corps there is training associated with the program based on "lean startup" principles (Ries, 2011) and Steve Blank's customer development methodology (Blank & Dorf, 2012), which require teams to interview 100 prospective customers as a means of developing products consumers really want.

Rationale for the Course

Initiatives associated with spurring entrepreneurial activity within universities have separate but often disparate goals when education, research, and business incubation are to be achieved concurrently. This is particularly true in the case of graduate entrepreneurship, where the premise of courses may be education, but the vetting of real technologies is often the desired outcome. Bill Aulet, the Managing Director of the Martin Trust Center Entrepreneurship at MIT has stated that it is important to reaffirm the role of entrepreneurship education, which is to create entrepreneurs (a near or long term outcome). This is in contrast to the primary goal of university commercialization and business incubation activities, which is to create companies in the short-term. The metrics associated with these goals are very different; educational goals have to do with changes in awareness, attitudes and knowledge, while commercialization and business development goals are measured in terms of numbers of patents and licensing agreements, startups formed, capital raised, and/or jobs created each year.

A graduate course for faculty and graduate student entrepreneurs was developed in 2011 when one of the authors wanted to share his experience after taking a multi-year, part-time leave of absence from his faculty position to work on a startup. The vision for the course was to leverage the experiences of a wide variety of faculty entrepreneurs that would inspire scientists how to make an impact on the world through translation and commercialization of their research. Attention was given to developing a course that addressed the wide range of complexities and realities associated with technology commercialization and entrpreneurship in a way that differentiated it from other entrepreneurship offerings. These occur on two levels: 1) the different nature of early-stage commercialization which is characterized by multi-year timelines, high levels of investment, and complex challenges related to commercialization strategies; and 2) the reality that involvement in entrepreneurship requires attention to many professional and personal considerations having to do with publishing/patenting, conflicts of interests, legal commitments, financial implications, time management, and work-life balance.

It was our observation that faculty, and students in particular, often jumped head first into these activities (working with the TTO, negotiating licensing agreements) with a limited understanding of the process, what is at stake, whose advice they should seek out, and who is protecting their interests. In many cases, researchers have to form companies (legal entities) in order have access to internal (university) or external funding and resources that support technology translation. In doing so, they often underestimate the business expertise required, believing the science will drive the commercial opportunity.

It is worth mentioning that academia is unique as it is one of the few work contexts where full-time employees have the opportunity to pursue outside employment. As John Biancamano, the General Counsel of Ohio States indicated, "employers outside of higher education tend to discourage or prohibit the pursuit of private business opportunities related to their employee's job responsibilities because these ventures give rise to a long list of potential problems" (Biancamano, 2002, p.2). Susan Carney Susan L. Carney former Deputy General Counsel at Yale University in a paper titled "Faculty Start-Ups: The Tangled Web" warned that "this private-interest aura inescapably, and properly, heightens the need for regular review and reexamination of the related conflict of interest questions, and of whether the academic research program has maintained appropriate goals or is being too heavily shaped by a non-academic agenda" (p.2). Some of these challenges are included in Table 1.

Table 1. Challenges Related to Student and Faculty Involvement in Commercialization and Entrepreneurship Activities

Challenges for faculty and institutions	Challenges impacting graduate students
• Questions related to conflicts of interest and research integrity • Managing time commitments to both university and venture • Segregating institutional resources for research vs. support of business ventures • Managing the relationship with colleagues to address continued desire for collegial sharing of research information. • Managing changes in research mission as some focus on technologies with commercialization at the expense of basic research	• Maintaining focus on dissertation research while being involved in a startup • Avoiding conflicts between thesis research and research that targets the new company • Maintaining healthy mentee/mentor relationship with the faculty advisor • Navigating employer/employee relationship with faculty advisor • Avoiding compromise of academic pursuits when students wish to become involved with the professors start-up (publishing) • Recognizing student contributions in inventorship and ownership agreements

Course Format and Content

The course is team taught by two faculty members. One from the Department of Agricultural and Biological Engineering with a joint appointment in Biomedical Engineering and who has Chemical Engineering background (male), and the other from the Department of Technology Leadership and Innovation (female) with a social science and management background. The format is a 16-week, 3 credit course that meets one evening per week for 2 hours and 50 minutes with additional consultation between the co-instructors and project teams occurring outside of lecture periods. The typical format each week is that the first half of class is devoted to a speaker, and the second covers the business principles associated with 16 elements the authors have identified to be critical components of a successful commercialization/start-up process (Table 2).

Speakers consist primarily of faculty entrepreneurs, with the addition of technology transfer office (TTO) directors; an IP attorney: a business formation attorney; a venture capitalist; and a market research librarian. Faculty entrepreneurs intentionally represent a wide variety of academic disciplines, and are at various stages of the commercialization and entrepreneurship process – ranging from early-stage licensing negotiations, to startups that have been acquired by larger companies. Faculty speakers are instructed to present their experiences as real world case studies that illustrate business principles, models of the translation process, commercialization strategies, and resources and people that have assisted them in these efforts.

Table 2: Critical Components of Successful University Startups

	Critical components of successful startup	Topics covered
1.	**Role of proof of concept vs. actual prototypes** There is a difference between an idea (university research), a business opportunity (with market validation), and a sustainable business venture (with revenues and profits).	• Importance of prototypes to credibility • Validation of market needs and wants • Perfectionism – a blessing or a curse
2.	**Timing: When to move up and when to move on?** There are three aspects of timing that are pertinent to commercialization within the university: 1) technology readiness; 2) market readiness; and 3) the larger context of career readiness.	• Differences between technology sectors, stages of research, and time to market (e.g., healthcare versus software, basic research versus applied) • Availability of funding • Context and environmental trends (e.g., energy policy, climate change)
3.	**Need for research discipline to achieve reproducibility of results and product robustness** The characteristics of the technology discipline must align with a viable business model to meeting customer needs and generate revenue. Process by which a business model is defined and developed.	• One product company versus platform companies (multiple products) • Nature of business models (technologies, subscription, • Components of business models: revenue sources, cost drivers, investment size, critical success factors • Business decisions and tradeoffs involved in business models • Evolution of business models over time due to environmental and technological trends
4.	**Building/finding business team to move from prototype to product** Identifying markets, resources, partners, and potential revenue streams. Moving from prototype to product.	• Identifying validated marketplace • Conducting primary and secondary market research • Examining buying decisions • Competitive analysis • Finding expertise (i.e., business team) to lead the process
5.	**Defining pathway (license vs. start-up)** Under certain conditions startups can provide better returns in terms of revenue and sponsored research than established companies	• Stage and nature of technology development • IP status • Attractiveness to potential partners • Availability of startup funding and resources • Creating a legal business entity • Founders agreement • Exit strategies
6.	**Freedom to operate analysis**	• At what stage of development to seek freedom to operate analysis

	Obtaining a legal opinion on whether the making, using, selling, or importing of a product/technology, in a given geographic market, at a given time, is free from potential IP infringement can be an important step investment for a university startup.	• Introduction to IP strategies
7.	**Sources of corporate and project capital versus organic growth** The type of capital required will depend on the type of venture being built, its stage of development, and capital needs.	• University or public sources of funding (seed funds, SBIR, STTR, NSF ICorps • Bootstrapping vs. private sources of capital (friends and family) and angel investors • Venture capital • Corporate (strategic) partnerships
8.	**Understanding investors** Venture capitalists are a significant source of funding technology startups and often provide business development value to startups beyond money.	• How venture capital works • Term sheets • What to expect when seeking venture capital and partnering with investors
9.	**Disclosures, provisional patents, patents, publications** IP protection has value to potential investors, yet can have limitations in terms of publishing for academic entrepreneurs and potentially their graduate students. Managing to minimize conflicts between patenting and timely publication.	• Purpose/mission of university technology commercialization activities • Services of the technology transfer office • Invention disclosure process • Provisional patents • Milestones • Financial arrangements • The need for speed
10.	**Role of networking and entrepreneurial eco-system** Researchers should find mentors who provide qualified advice and open doors	• Entrepreneurial networks • Alums, mentors, fellow faculty • Roles of attorneys, accountants, consultants, and other service providers
11.	**Managing conflicts of interests** Faculty involvement in commercialization changes his/her relationship with the institution.	• Conflict-of-interest policies • Disclosure and approval procedures • Use of university resources • Impact on research (direction/integrity) • Impact on student advising
12.	**Financial and personal costs (and benefits) to founders of new venture** Faculty involvement in commercialization and startup activities impacts their relationship with and view of their institution and associated responsibilities.	• Personal factors to consider: goals, resources, time, talent, tolerance for risk and expected rewards • Impact on publishing, tenure, promotion • Relationships with administrators, peers, and students • Maintaining balance
13.	**Effective communication**	• Effective communication for different audiences (scientific versus business) • Formats for presentations and pitches

	Success as an entrepreneur is determined in large part to one's ability to communicate.	• Oral versus written communication
14.	**Leadership** Entrepreneurship requires inspiring the team with vision, energy, and insight to achieve a common goal.	• Skillset associated with being an inventor/innovator versus CEO • Identifying and attracting talent

Grades are based on attendance and class participation, two reflection papers, and a team project consisting of a commercialization plan/pitch for translating technology from laboratory to a commercial setting. Reflection papers require students to an apply what they have learned in classroom lectures, directed readings, and speakers in relation to items 1 through 16 above. These are approximately 1200 words in length. The final project is developed by teams of three people. These are based on technologies on which individuals in class are working as part of their research or are otherwise of common interest to the team. Working in teams is essential since not all students have research that lend themselves to such a project. It also brings a multidisciplinary perspective to each project as there is low likelihood of team members being from the same academic discipline.

All PhD students are required to do the assignments and no students are allowed to audit the course. Faculty, post-docs and research scientists do not formally register for the course as we currently lack a facile mechanism to do so. The agreement is that they, too, must attend all the classes for the full duration (not just for the guest speakers) and fully participate in the class. They serve as team members with students on commercialization projects and provide an important element of mentorship and professionalism among the student teams with whom they work.

Assessment and Outcomes

To understand the backgrounds of participants, their motivations for taking the course, and measure changes in entrepreneurial intention and self-efficacy, data is collected at the beginning and end of the semester through pre- and post-course surveys. These surveys were created based on experience in developing entrepreneurship education surveys for other populations (Duval-Couetil, Gotch, & Yi, 2014, in press; Duval-Couetil, Reed-Rhoads, & Haghighi, 2010, 2011). The scales and survey items focus on collecting data related to: demographic and background characteristics; entrepreneurial intention; knowledge and skills; and venturing and technology self-efficacy (Lucas, Cooper, Ward, & Cave, 2009).

Descriptive statistics were analyzed to understand the characteristics of the students in the programs. To assess the impact of the program, the differences between pre- and post-survey of the students who took the course were examined using paired t-tests. Effect sizes (Cohen's d) were calculated based on the formulas of Borenstein (2009). Dependent variables were entrepreneurial intention, perceived knowledge and skills related to entrepreneurship, and entrepreneurship self-efficacy.

Question 1: *What are the characteristics of participants in the course?*

Over a four year period from 2011-15, over 100 faculty and students participated in the course, which was offered once per year. Results are based on a sample of 78 participants who completed both course entry and exit surveys over this period.

Of this sample, 72% were PhD students, 13.4% master's degree students with intent to pursue a PhD; 8.5% faculty, and 2.4% post-docs. Participants came from the disciplines of Agriculture and Biological Engineerring (16.7%), Electrical and Computer Engineering (7.7%), Mechanical Engineering (6.4%); Chemistry (5%), Computer Science (5%),and the remaining almost 60% coming from a wide variety of STEM fields including industrial, chemical, biomedical, civil, environmental, and materials engineering. Other fields represented have included basic biomedical sciences, veterinary medicine, management, education, philosophy, and the arts. The high percentage of Agricultural and Biological Engineering students reflects the home department of one of one of the course professors.

Participants were asked a number of questions related to their previous experience with technology commercialization and entrepreneurship. Less than 20% had any experience with technology commercialization or entrepreneurship, however, almost one quarter were in the process of protecting intellectual property. Over a third (38.5%) had worked in industry, 62.8% knew someone who started a venture; and 50% knew a faculty member who started a venture (Table 3).

Table 3. Entrepreneurial Backgrounds of the Participants (*N*=78)

Students who have experienced the following:	Frequency (%)
Entrepreneurial courses at Purdue	13 (16.7)
Entrepreneurial courses at another institution	9 (11.5)
Teaching entrepreneurial course	1 (1.3)
In the process of protecting IP	19 (24.4)
Filing disclosure or patent	15 (19.2)
Working in industry	30 (38.5)
Starting an own venture	9 (11.5)
Worked in a start-up--Pre-revenue	13 (16.7)
Worked in a start-up--Post-revenue	12 (15.4)
Participating in an Initial Public Offering	0 (0.0)
Knowing someone who has started a venture	49 (62.8)
Knowing faculty member who started a venture	39 (50.0)
At least one parent who is an entrepreneur	20 25.6)

Question 2: *What are their motivations for participating?*

Participants were asked about their entrepreneurship-related goals as a means of understanding their motivation for taking the course. These were measured using a four-point scale with 1 = not at all interested, 2 = not very interested, 3 = somewhat interested, 4 = very interested. Findings show relatively minor changes in participants intention to start ventures as a result of the class. The greatest change was for the item "start a venture within five years" where a number of participants were "very interested" in doing so prior to beginning the class and were "somewhat interested."

Table 1. Pre- and Post-Program Comparisons for Entrepreneurial Intention

	Frequency (%)								*Mean (S.D.)*			
	Pre				Post				Pre	Post	*t(77)*	*d*
	1+	2	3	4	1	2	3	4				
Starting a venture while at Purdue	3 (3.8)	18 (23.1)	33 (42.3)	24 (30.8)	6 (7.7)	12 (15.4)	38 (48.7)	22 (28.2)	3.00 (0.84)	2.97 (0.87)	0.32	.03
Starting a venture within five years	3 (3.8)	9 (11.5)	20 (25.6)	46 (59.0)	1 (1.3)	12 (15.4)	30 (38.5)	35 (44.9)	3.40 (0.84)	3.27 (0.77)	1.56	.16
Starting a venture after five years	2 (2.6)	1 (1.3)	22 (28.2)	53 (67.9)	0 (0.0)	4 (5.1)	22 (28.2)	52 (66.7)	3.62 (0.65)	3.62 (0.59)	0.00	.00
Participating in innovation or competitions	2 (2.6)	14 (17.9)	31 (39.7)	31 (39.7)	4 (5.1)	9 (11.5)	36 (46.2)	29 (37.2)	3.17 (0.81)	3.15 (0.82)	0.12	.02

Note. +1=not at all interested, 2=not very interested, 3=somewhat interested, 4=very interested

Question 3: *To what extent did their skills and knowledge related to entrepreneurship improve?*

To measure this items from (Lucas et al., 2009) *technology and venturing self-efficacy scale* was used (see Appendix A). It measures *venturing self-efficacy* based on survey items that reflect the skills needed for developing innovation for the launch of new ventures such as recognizing and evaluating new opportunities, estimating costs of new projects, marketing and selling, and personnel selection. It measure *technical–functional* self-efficacy measures with survey items related to performing science and technology tasks that play a role in developing innovation. Survey items ask respondents to rate their confidence on a scale of 1 to 10. Pre- and post-measure for both measures were significant, with an increase from 4.92 to 7.62 post for *venturing self-efficacy* and 6.88 to 8.82 for *technology-functional* self-efficacy.

Question 4: *How satisfied were students with the course?*

Satisfaction was measured through course evaluations which were very positive as well as qualitative data collected through the post-survey. Themes in the qualitative responses indicated a high level of satisfaction with the speakers, the opportunity to learn through their experiences:

> *It afforded me the chance to come into a class with an engineering/science background and learn through people of similar backgrounds how entrepreneurship works. Being able to learn through the experiences of other people in an intimate class setting is invaluable and I do not think I could have had the same opportunity in any other departments or schools.*
>
> *The lecturers all have different insights about their cases and after hearing many of them connections between what they were saying, the readings, and other material started to emerge.*
>
> *The variety of experienced speakers seemed to complement the learning process very well! If there exists a "correct" order for the presentations, this was it.*
>
> *The guest speakers gave an invaluable opportunity to listen to their experience, up close, whatever the outcome.*
>
> *Having experts come in and give testimony to their experience. Its difficult to put a value on the opportunity to have an open floor Q and A session with respected professionals.*

It also made some think differently about research:

> *I enjoyed thinking about research in a different way and the possibilities for research beyond a scholarly work. When the fastest realization of the implications of research are twenty years down the road, it can be difficult to see the end result, and understand how it will benefit people. However, in this class, we have learned how to have people in mind during the entire research process. This makes the research problem more realistic (more about utility), and forces us to shape our problems into problems that can be answered. This process in and of itself can lead to further discovery.*
>
> *The ideas and thoughts related with business, different from science, this will keep diversity of my thinking.*
>
> *It really helped me start thinking about the customer's need and motivations.*

While the emphasis of the course was more education than incubation, learning business concepts and having to work through real-world projects was of value:

> *This course led me to write a business plan as a term project, which is really important and necessary for further developing my ideas and facilitating to go to the next step.*

I'm also glad we worked on a business plan outline, I think it was an excellent project to start to work on and get our hands a little dirty with.

The potential impact on personal and profession development was also evident:

The whole process for a start up is very useful. In addition, I learned the importance of the soft power of social skills and networking.

This course offered me great opportunities to communicate with people doing real business with an academic background. Their experience is quite different from those traditional businessman. Also the course is well organized so that at the end of semester, many faculties and students get to know each other or even become friends.

It showed me that starting my own business is not my preferred strategy. It showed me that the amount of money required to start my own business is quite huge, though the amount of money required to merely license a technology is more approachable.

Multi-disciplinary teams. Seeing the dynamics within my own team as well as the other teams. Experiencing the growth and development of the various business ideas.

To know that being an entrepreneur is not impossible, and what it takes to be an entrepreneur.

"Most" of the people in the class always appeared to want to be there. This is motivating and great.

How motivated I felt after leaving class.

Discussion

In order to demonstrate their value and impact on communities and the economy, universities are encouraging students and faculty members to become involved in technology commercialization and entrepreneurial activity. Given changing professional roles in academia and industry, there are benefits to graduate students and faculty who have knowledge of or experience with these activities. Data collected from participants show a number of positive outcomes including greater awareness of the technology commercialization process, improved venturing and technology self-efficacy, a different way of examining their research, and the value of the experience to their professional development.

This course is unique in several ways. It does not rely on the participation of MBA students, and therefore scientists must engage and acquire skills related to the business aspects involved. It also addresses the concerns of time to devote to non-research activities that students have. Research shows that some PhD students report that they perceive that they are able to spend only 1-3 hours a week on professional development activities (Wheadon & Duval-Couetil, 2014).

Many students contact us prior to registering for the class to inquire about the work required outside of class time. Our vision is that the readings and assignments should complement what students are doing in their labs, and not detract from it and this is what is communicated to prospective students. Less than one-quarter has experience with technology commercialization or entrepreneurship prior to taking the course, suggesting the learning ojectives are appropriate for this population, many of whom were not deep into the process, and generally wishing to familiarize themselves with it.

On some levels, this might not vary greatly from other graduate courses on technology commercialization, in terms of the business concepts and processes that are put forth. However, the goal is to paint a larger picture for students and faculty of how technology commercialization fits into their careers, by asking questions that spur rich discussion, such as:

- What is the intent of the university's commercialization activities?
- What are the characteristics of those who get involved and succeed?
- How does the process really work?
- Who can one go to for unbiased advice or assistance?
- How does involvement change relationships between faculty and institution, and fauclty and students?
- What is the return to the university?
- What is the return to the individual?

Interestingly, while the assessment data showed improvements in self-efficacy, it also shows that participation in the course didn't significantly increase their short-term interest in pursuing technology commercialization activities. If anything, it tempered them. These findings suggest that the class gives particpants a better understanding of the complexities associated with commercialization and entrepreneurship within the university. The fact that some participants changed their responses from "very interested" to "somewhat interested" may suggest they will be more inclined to pursue these activities when and if they feel prepared and ready.

There has been much excitement surrounding entrepreneurship in recent years. The lure of company ownership and financial gains is attractive, as is attention entrepreneurial students and faculty can receive from the media and administrators. Interestingly, the metrics of the academic and business development enterprises of the university must be reconciled. The former is focused on scholarship academic success, degree completion, and placement, while the latter is focused on shorter-term venture development.

Interestingly, some have recently called for students to put off involvement in startups even at the MBA level. A recent article in the Wall Street Journal titled "Stanford's Business School Tells MBAs to Wait on Startups" describes university administrators who are encouraging students to curb their startup ambitions until they graduate from college so they can focus on course work and campus life. Administrators feel that students are giving up valuable internship and professional opportunities and they point to the reality that many ideas on which students work are not ready for "prime time, the ventures have limited market potential outside of the university walls, and that most fail."

Given the interests of various stakeholders involved in technology commercialization, tensions exist that warrant further examination and consideration. Some of these include: balancing full-time employment as an academic with entrepreneurship activity; managing faculty/advisor and student/employee relationships; balancing students academic and financial interests; recognizing entrepreneurial activity in the promotion and tenure process; and how the institution has the resources to oversee these activities given their scope and the interests of all parties involved. There are many interesting philosophical questions that are yet to be answered, as well. Nonetheless, awareness of an involvement in entrepreneurial activity can be a valuable complement graduate education.

CONCLUSION

Emphasis on technology commercialization is here to stay given changes in economy which affect academia and industry. It is essential to for graduate students and faculty understand the process of translating reseach into commercial products whether they participate directly or not. We believe this course has served as an efficient and novel way to deliver an overview of the technical and business knowledge required to participate in technology translation activities, at the same time providing a forum for interdisciplinary interaction and professional development. Given the human and financial resources it takes to bring innovation to market, the more awareness of the complexities and best practices can provide efficiencies for all stakeholders involved, the more likely that all concerned will feel better prepared to measure impact and return on investment of commercialization activity in a university setting.

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Appendix A

Venturing and Technology Self-Efficacy Scale

Lucas, W., Cooper, S., Ward, T., & Cave, F. (2009). Industry placement, authentic experience and the development of venturing and technology self-efficacy. Technovation, 29(11), 738-752.

For each statement circle a number from 0 (0% not at all confident) to 10 (100% completely confident) to indicate how confident you are to perform that skill or ability now.

Know the steps needed to place a financial value on a new business venture

Pick the right marketing approach for the introduction of a new service

Work with a supplier to get better prices to help a venture become successful

Estimate accurately the costs of running a new project

Recognize when an idea is good enough to support a major business venture

Recruit the right employees for a new project or venture

Convince a customer or client to try a new product for the first time

Convert a useful scientific advance into a practical application

Develop your own original hypothesis and a research plan to test it

Grasp the concept and limits of a technology well enough to see the best ways to use it

Design and build something new that performs very close to your design specifications