AC 2011-1232: INTERDISCIPLINARY STEM-BUSINESS GRADUATE CERTIFICATE IN ENTREPRENEURSHIP PROGRAM

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Carol coordinates the entrepreneurship efforts at the University and has mentored more than 30 undergraduate and graduate business plan teams since 2002. In 2010, Carol's teams won more national business plan competitions than teams from any one university in the 25 year history of the competitions. Carol has won two national awards for innovation in entrepreneurship pedagogy and won the prestigious University of Arkansas Alumni Association Faculty Distinguished Achievement Award for Teaching in 2009. She earned a Ph.D. in Strategic Management with an Entrepreneurship Concentration from the University of Georgia in 1988.

Interdisciplinary STEM-Business Graduate Certificate in Entrepreneurship Program

Abstract

Efforts to merge entrepreneurial training into graduate STEM education face many obstacles to implementation. These include curriculum crowding, STEM faculty opposition to time spent outside the research laboratory, STEM student focus on traditional opportunities in large technical organizations, and lack of coordination between STEM departments and colleges of business.

This paper will describe efforts to first embed entrepreneurial research commercialization training into an interdisciplinary science/engineering graduate program. We will then describe the creation of a more extensive Graduate Certificate in Entrepreneurship program housed in the College of Business, its interaction with interdisciplinary student teams participating in national business plan competitions, and how the teams have moved from student business plans competitors to start-up owners. The current status and future opportunities for the student-led companies that have launched from the Graduate Certificate in Entrepreneurship program will also be addressed.

STEM Graduate Programs – Difficulties in Embedding Entrepreneurial Training

It is widely recognized that worldwide leadership in technology-based economic development requires a strong education system in the STEM fields as well as strong research at the leading edge of technology. What is less well recognized is the negative impact on our future economy from weak entrepreneurial training of our STEM students as part of their formal education.

There are also structural barriers to adding entrepreneurial training to STEM graduate curricula. The first and most obvious is the ever expanding body of technical knowledge that must be comprehended in some fashion in the curriculum for a particular graduate program by that program's faculty members. Attempts to add specific entrepreneurial curricular elements to these STEM programs, without increasing the time to degree completion, face intense opposition from faculty who are strongly focused on the technical professional preparation of their students.

The second structural barrier is a lack of entrepreneurial curricula for non-business graduate students, curricula that would focus on practical operational knowledge needed by new entrepreneurs. These curricula cannot be effectively created by colleges of business without strong input from STEM graduate programs, just as it cannot be effectively created by STEM programs without business faculty expertise. An added difficulty is college of business accreditation risk from any apparent business-related curricular elements not housed in the college of business.

Added to these structural barriers are perceptions of low return on the time investment needed by the STEM students to include entrepreneurial in their own degree plans. These perceptions are shared by both the STEM students and faculty, although they manifest themselves in different ways.

STEM students most often view themselves as leaving graduate school to join an existing technical organization, and as such see little value in training to launch their own company. This is coupled with the fact that technologists generally do not hesitate to tackle a problem of great difficulty, but only if they feel they understand the nature and general scope of the problem they are tackling. Therefore the lack of entrepreneurial education leaves the STEM students feeling that entrepreneurial opportunities are outside their scope of professional activities, and sometimes feel that entrepreneurial development of discovered technology to be almost a perversion of their primary task – to create new technology and products for society that should be sold at a price of 120% of manufacturing cost regardless of value provided.

This problem of STEM student perception is exacerbated by STEM faculty whose career performance metrics in the academic arena are grants awarded, research publications, and support of the educational mission of the institution. In very few institutions are entrepreneurial successes considered in the faculty tenure and promotion discussions, much less in annual reviews. These faculty performance metrics are in opposition to a STEM graduate student spending time in any classroom instead of the research laboratory, much less classes that are outside the normal expectations of hiring managers. Even faculty who are directly engaged in commercializing their own research push back against students taking classes such as these until their "real graduate work" is completed.

Overcoming these barriers requires a multi-faceted approach, some of which have been successfully implemented at the University of Arkansas (UA) and some of which have not. This paper will concentrate on describing how the appropriate entrepreneurial educational paths for STEM students were created and implemented, what positive outcomes have been observed, and how the UA administration is reacting to student entrepreneurial success.

Research Commercialization – A Narrowly Focused Introductory Course

In 1998, an interdisciplinary science-engineering graduate program in micro to nanoscale materials, processes, and devices was created to allow students interested in its field of study to take courses across multiple departments that would benefit their career preparation. Operationally, the graduate program was defined to emulate an industrial work group atmosphere, both in its daily operations and in its management education.

It should be noted here that the faculty of this new graduate program recognized that the technical content of this interdisciplinary grad program could not be significantly reduced as compared to traditional STEM grad programs on campus, but at the same time managerial and entrepreneurial education must be added to meet the demands of the hiring managers in large technical organizations. The only answer to this conflict was to increase the number of course hours required by the Microelectronics-Photonics (μEP) grad program's students to fulfill their degree requirements.

The μEP M.S. technical content curriculum was reduced by one course, and seven hours of required management-related courses were added. The Ph.D. technical content curriculum was unchanged, but three hours of a management-related course beyond the M.S. curriculum was added. In addition, all students were required to take a three-hour course specifically in research commercialization that was developed with financial support of the NCIIA.

This course in research commercialization was co-developed by Prof. Ken Vickers and Dr. John Todd. This brought the experiences of an industrial technologist to merge with the entrepreneurial education experience already developed in the Management Department of the Walton College of Business. The resulting course content was highly specialized in its focus, including the recognition that starting with a research result and then trying to locate a societal need it could meet is typically listed as one of the top five reasons that entrepreneurial ventures fail.

At this point it should be emphasized that the µEP faculty and student hesitancy to invest time in this course was overcome by brute force – the course was embedded as a core required course for all students in the graduate program. The students' self-assessment of lack of any interest in starting their own business as an entrepreneur was met with continuous class discussions that the methods and approaches being taught not only applied to an entrepreneurial startup, but also to intrapreneurial activities in large organizations. These intrapreneurial activities (product development, project management, research and development, etc.) are all career paths that are considered preferable career paths for STEM graduate students, which increased the students' expectations of reasonable personal ROI for the time spent in the class activities.

It is also emphasized to potential students that they will be required to take more hours than typical STEM students, and that they will be expected to participate in more non-academic training activities. The students receive a full explanation of what we have added to the curriculum, why we feel it is important, and the value that they will gain that has already been demonstrated by prior graduates of the program. After thirteen years of the program, all our applicants have accepted this extra cost in time and expenses as being worthy of what they expect to gain in professional preparation.

While acceptance of the course by other STEM graduate programs at the UA has been slow, recent activities in the College of Engineering have demonstrated an increased administration interest in promoting the course for the good of its students in traditional engineering graduate programs. The course is now being promoted in two departments as a valid substitution for one technical content course in their M.S. curricula, and the College of Engineering has requested that the course be modified and recorded for use in its distance education M.S. Engineering and M.S. Operations Management graduate programs. Unfortunately, interest in the course by the science graduate programs' administrations has not yet appeared.

The impact of the course in µEP students has been difficult to quantify, but anecdotal evidence from µEP alumni provide illustrative examples of how the course content has affected their professional decisions:

- One Ph.D. student started his own company based on his Ph.D. research upon graduation. After six years he has been recognized as one of the "Top Forty Entrepreneurs in Arkansas Under Forty", his company employs about 25 B.S., M.S., and Ph.D. STEM graduates of the UA. This includes one M.S. and one Ph.D. graduate of the µEP grad program. His company has just leased manufacturing space for their first large volume commercial product.
- One Ph.D. student started his own company based on licensed intellectual property from a UA research professor. This company's business plan was developed to fulfill the business plan competition requirement for the Graduate Certificate in Entrepreneurship

(discussed later in this paper). He now employees one Ph.D graduate, one current Ph.D. student, and one current M.S. student from the µEP grad program.

- One Ph.D. student accepted a position as Product Development Manager at a mid-stage company (~140 employees) specializing in custom MEMS devices.
- Three M.S. graduates went to work for research-based startup companies run by their major professor. After about two years in that environment one has now moved to a Product Development position in a major medical devices company, one has move to a technology development position in integrated circuit manufacturing, and one has moved to a startup company in his home country.
- One local small technology company that had existed on developing technology for NASA has now hired two Ph.D. and one M.S. <grad program> graduates. These three technologists are leading the company efforts to modify their space technology into products for large volume commercial applications.
- One Ph.D. and one M.S. µEP graduate has been selected for Engineering Manager positions within four years of their degree completion at a major producer of advanced communication devices.
- Many other alumni of the µEP grad program that are in more traditional technologist positions have communicated the usefulness of fully understanding the commercialization process, even if their job description does not include strongly intrapreneurial responsibilities.

While these successes are pointed to with pride by the students' major professors, each professor generally still perceives their current students' participation in this course as a distraction from the primary work in the laboratory. The historical approach that research is the most important educational element of the grad school experience, coupled with the lack of research commercialization benefit in the tenure and promotion evaluations, has prevented significant adoption by individual faculty members of entrepreneurial education as being important to their students – even when they strongly support it in program review discussions on whether it should remain as part of the core curriculum.

Expanding Entrepreneurial Education through a Certificate Program

While the Research Commercialization course provided valuable training in understanding the full scope of knowledge needed to be a successful entrepreneur, it did not result in an academic credential that demonstrated its value to the hiring market. In the spring of 2004, the College of Business and the College of Engineering began developing a 12 credit-hour Graduate Certificate in Entrepreneurship for non-business majors. Although the program was initially conceived of as an area of emphasis for Engineering Ph.D. students, faculty and students from throughout the university recognized its potential, and the Certificate was opened to any non-business graduate student.

Approved in 2007, the Graduate Certificate in Entrepreneurship includes an introductory class (Foundations of Business for Entrepreneurs) that introduces non-business students to basic business concepts as they apply to entrepreneurs. Following successful completion of this class, students take a two-course sequence (New Venture Development and Business Plan Project) with graduate business students. These classes address opportunity recognition and new venture

development and funding. The fourth class in the Certificate program is an elective class that can be taken within or outside the student's major classes.

A key component of the Graduate Certificate is the interdisciplinary teams formed for the New Venture Development class. These teams work together to develop a business plan for a start-up that typically commercializes a university technology. The engineering/science/agriculture students provide the technical expertise needed to assess available technologies and develop them for the marketplace, while the business students develop marketing plans, competitive analyses, and financial viability assessments. The teams refine their plans over several months and then submit them to national and international business plan contests; almost all of the teams advance to the oral presentation rounds at these competitions. Over the past four years, these teams have had significant success, winning over $1 million in cash, investments, and in-kind prizes, raising several million dollars in funding, and starting four of the companies proposed in the plans developed for the class. The remainder of this paper will discuss how the teams are formed and difficulties in team formation, strategies to overcome team formation problems, why the teams have been so successful in student business plan competitions, and the success of two of the teams subsequent to the competitions.

Formation of Inter-disciplinary Teams

Students who successfully complete the Foundations of Business for Entrepreneurs course in the spring semester are invited to continue in the Entrepreneurship Certificate program. Science, engineering, agriculture, and design students, among others, have participated in the program over the past five years. The non-business students meet business students, who include full-time MBA, part-time MBA, and Masters of Accountancy students, during the second course in the Certificate program, New Venture Development. Because the students must quickly form groups to work on their projects (note that they are not assigned to groups), significant time is devoted prior to and at the beginning of the semester to helping students get to know each other. For instance, all students are invited to an informal pre-class social so they can meet each other in a relaxed atmosphere. During the summer, students post resumes on Blackboard so that they can identify potential teammates based on background and expertise. In addition, students use the Discussion Board on Blackboard to propose ideas, learn about other students' areas of interest, and get a sense of working styles. Several introductory activities, such as three-minute "speed dating" sessions, class introductions, and in-class group projects, are conducted during the first two class sessions.

As might be expected, the gulf between business and non-business students is wide at the beginning of the semester. Both groups are most comfortable interacting with their disciplinary peers, but interdisciplinary teams are critical to success in business plan competitions and in the start-up businesses that ultimately emerge from the classes. To increase students' understanding of the importance of interdisciplinary teams, we show videos discussing the necessity of diverse backgrounds in successful teams. (We have found the free Stanford Technology Venture Program videos to be particularly good at highlighting this information.) Perhaps most important, we bring back students who have completed the program in the past to talk to the incoming students. The non-business students frequently mention how they overcame their skepticism regarding the value of business skills, such as marketing, at the beginning of the process. Business students bring up how hard it would have been for them to understand the technical and scientific components of their plans and answer investor questions without their

non-business teammates. Even though they may not appreciate how important inter-disciplinary teams are at this stage of the process, most students take their predecessors' advice and seek out teammates with a variety of backgrounds and expertise when they are forming their teams – in spite of their discomfort interacting with students different from themselves.

Moving from Student Workgroups to Start-up Teams

The first significant decision that must be made by the teams is the selection of an idea; very few students come to class with an idea they want to pursue as a start-up business. Our most promising ideas have come from IP generated at the flagship research and medical universities in the state. Officials with the Technology Licensing Offices at these universities present available IP to the students during one of the first class sessions. Some teams form around one of the ideas, while other teams form prior to selecting an idea and then consider the IP that best fits their background and areas of expertise.

It is during the evaluation of ideas that the teams first fully appreciate the value of having both STEM and business students on the team. STEM students focus on the technical feasibility of the idea and the cost of validating and advancing ideas scientifically, while business students focus on the size of the market and the cost of developing the product and taking it to market. Teams quickly realize that they cannot get a full picture of the viability of turning these ideas into businesses without input from both types of students.

Within six weeks of the beginning of the fall semester, students must form teams, evaluate ideas, and turn in the product section of their business plan. An additional section of the business plan is due each week following that, with the first draft of the entire plan due before the Thanksgiving break. This intense timeline either creates highly functioning teams or pulls teams apart. It is typical to lose half the teams from the fall semester to the spring semester. The most common reason teams do not enroll in the Business Plan Project class in the spring is that they could not form teams that were committed to doing the work necessary to turn their business plans into start-ups that could be competitive at the competitions and in the search for investment capital subsequent to the competitions.

The Business Plan Competitions

National student business plan competitions started in 1987 at the University of Texas-Austin. The caliber of the business plans at these competitions has improved so dramatically that the UT competition was renamed Venture Labs Investment Competition (VLIC) from Moot Corp this year because the businesses presented at the competitions are no longer "moot." While the exception used to be that the winners started their businesses, the exception now is that winning teams do not start their businesses. The 20 national and international competitions that feed into VLIC are judged by top-tier investors and entrepreneurs and expose students to the world of raising money for start-ups. Because students are given the opportunity to present before investors who might really invest in their companies, the competition just to be accepted to present at these contests has become intense. Teams from the best business schools in the world, including MIT, Harvard, Stanford, Carnegie-Mellon, and the London School of Economics, compete. As an example of the intensity of the competition, more than 420 teams competed for 42 slots at the 2010 Rice business plan competition, where the total prize package was over $1

million. In 2010, more than 200 teams competed in the oral competition rounds at the feeder competitions.

The University of Arkansas is not the type of school that has typically done well at these competitions. It is a mid-sized state university with a small MBA program and underfunded research activities. Our success is largely attributable to four factors: our interdisciplinary teams give our teams a broad perspective not possessed by their competitors, we have a strong managerial MBA program that attracts top young talent who have moved into the area to work for major corporations with offices nearby, community business leaders and university technology experts give freely of their time to help mentor the teams, and our students work extraordinarily hard. Regardless of the other factors, no team can be successful without putting in the required work, so we will describe the activities undertaken by the teams prior to competition.

Before submitting their business plans to the competitions, the teams will typically revise them 20 or more times. When the teams get new information about their technologies and the market, the revisions are extensive. Other revisions are relatively minor, basically involving rewording of sentences so that the plans conform to 10-20 page space limitations. This attention and work on the written plans have been recognized with several "Best Written Plan" awards over the past few years.

The spring semester Business Plan Project class focuses on three activities – revising the written plan, preparing the oral presentation, and competing in business plan competitions. Each team goes through numerous dry-runs in front of knowledgeable "judges," including lawyers, accountants, investors, and science/technology experts. The transformation of the oral presentations from the first session to the last competition is remarkable. As with the written plan, students revise their presentation after every dry-run and competition round. By the end of the "competition season" in May, most of the students have presented their plans more than 50 times. They become intimately familiar with all parts of the business through this process and, by the end of the semester, it is very common for the STEM students to answer financial questions and MBA students to answer technology questions. They develop a deep familiarity with concepts, principles, and language that they would have thought impossible six months earlier. We believe it is impossible to achieve this depth and breadth of understanding through normal classroom activities.

While our teams have done well at business plan competitions since 2004, garnering many 2nd and 3rd place finishes, our success at the competitions in the past two years has been particularly noteworthy. In 2010, we won nine of the 15 national business plan competitions we entered, including the two most prestigious competitions in the world. We also swept the awards (1st, 2nd, 3rd, Innovation, elevator pitch) at our state and regional competitions. In 2009, we won four national business plan competitions (one with an interdisciplinary undergraduate team), and our state and regional competitions. In the past two years alone, our students have won over $1 million in cash (>$300,000), investments from the competitions, and in-kind prizes. While in-kind prizes are not viewed with as much excitement as cash at the competitions, our students have found them to be invaluable as they transitioned from student team to start-up.

From Competitions to Start-ups

We will close by discussing the successes of two of our 2010 teams to illustrate why many officials in our state believe that the student business plan teams and the companies that result from them will play a key role in the state's economic development. Each of these teams was interdisciplinary and had students from the Certificate program. One team had two Microelectronics-Photonics (MEP) Ph.D. students, an MBA student, and a Masters of Accountancy student, while the other had two students with biology Ph.Ds. (one was pursuing the entrepreneurship certificate and one was pursuing an MBA) and two MBA students. All four members of the second team are still actively involved with the company, but only the MEP members of the first team continue to be involved in the company's activities.

The first team's plan was built on a technology that will reduce the cost of goods sold of solar panels by 26% while also increasing conversion efficiency. The second team is developing a breakthrough treatment for osteoporosis. In both cases, the teams licensed their technology from our university.

The teams have undertaken similar approaches to public fund-raising but different approaches to private fund-raising. Both teams applied for and were awarded technology grants and investment tax incentive grants from the state. Both have applied for and received federal research funding – a $150,000 SBIR Phase I grant for the solar company and a $2.3 million DoD grant for the osteoporosis firm. The solar company raised $200,000 in private funding (matched by $200,000 in state funding), but has turned down an offer of $1.5 million in private funding because of the terms offered. They have entertained investment offers, but are largely content to use their existing funds to further validate and improve their technology and increase their company's valuation.

The osteoporosis company is actively seeking private investors and has made investment presentations across the country. They are part of a local technology incubation group that provides them with grant-writing, legal, and accounting assistance. They anticipate closing on a $1.5 million funding round in the next two months. They are also optimistic about receiving at least one other $1 million+ federal grant in the next few months. Their plan is to take the drug through Phase I trials and sell the company afterward. They continue to receive very positive results from animal trials.

While, on average, only one of ten companies like these will give their investors strong returns, the students are optimistic about their chances in the future. The business plan competitions prepared them for the tremendous work it takes to make a company successful. They exposed the students to investors and experts, several of whom have continued to interact with the students and serve as mentors to them. While it is impossible to fully prepare students for start-up life in the course of two courses, the New Venture Development and Business Plan Project courses have exposed our students to opportunities they never anticipated, resulted in four full-time, high-wage jobs, and set them on a path to successfully build their businesses into companies with very attractive long-term prospects.

Impact on University of Arkansas Campus Culture

The efforts described in this paper were only two of the efforts in a loosely coordinated grass-roots community of UA faculty, administration, and staff working in concert with local political, community and business leaders. The accumulation of these complementary efforts over the last

fifteen years is resulting in a mosaic of success in promoting entrepreneurial efforts in the northwest Arkansas region.

Some of these additional efforts include:

- Chancellor John White's support of interdisciplinary graduate program formation beginning in the late 1990's. The current central administration continues to support these programs, most of which are now among the graduate programs with the highest enrollment of students on our campus.
- Aggressive pursuit of entrepreneurial resources by the μEP grad program, including an NCIIA class development grant, two NSF Partnership for Innovation grants, and inclusion of research commercialization support in major research grants such as NSF MRSEC.
- Active promotion of entrepreneurial education in Engineering PhD curricula by Dean Ashok Saxena and Dr. Ajay Malshe in partnership with the Walton College of Business.
- A central administration change in mission emphasis of the UA Technology Licensing Office (http://www.uark.edu/ua/tlo/) from "fastest financial return on investment" to "delayed financial return through equity ownership of self-commercialized UA IP local company startups".
- A change in the format of the campus Patent Committee meetings from the faculty members being the primary reviewer of patent disclosures to instead being an oversight board reviewing the analysis and recommendations of the Office of Technology Licensing. This did require an increase in the number of professional analysts in that organization and the UA administration becoming a patient investor in self-commercialization efforts.
- Creation of the Genesis technology business incubator (Genesis) in the mid 1990's, an early stage company facility (Innovation Center) in 2005, and a company expansion facility (Enterprise Center) in 2010. These UA-Community partnerships are co-located on the Arkansas Research and Technology Park (http://www.uark.edu/ua/artp) campus three miles south of the main UA campus. A company locating in the ARTP campus has full access to UA research support infrastructure such as library, broadband internet, teleconference facilities, UA fabrication user facility laboratories, etc.).
- Growth of local private companies, such as Virtual Incubation Company, who partner with UA researchers to create a company through licensing of the faculty member's IP from the UA. This gives faculty with an interest in self-commercialization, but with no interest in launching into an entrepreneurial lifestyle, a method to act in the CTO role without abandoning his or her academic career.
- Increased emphasis at the state government level in creation of high value industry in Arkansas, including financial support through the Arkansas Science and Technology Authority (http://asta.ar.gov) and programs such as corporate income tax credits for early stage companies.
- Creation of state-wide company associations such as the Arkansas Venture Forum (http://arkansasventureforum.com). This organization has formed an industrial entrepreneurial community to support early-stage Arkansas companies, with a goal of accelerating their development to the point of company stability.

- Seed funding from Central Administration to establish an Office of Entrepreneurship in 2010 that supports student efforts at commercializing IP.

Any of these efforts taken in isolation would not result in significant change of a campus culture, and, in fact, the efforts at the University of Arkansas had not been coordinated through any formal upper level authority until the past few months, when an Office of Entrepreneurship was created (http://vpred.uark.edu/223.php). Instead there has been a self-organization of passionate individuals from all community areas, each creating a strong effort in their area of expertise or interest that utilizes the other developing efforts to leverage their own success. Communication within this community has not been provided by any formal network or hub, but rather through a rather traditional approach of tapping into the network to locate partners or other support for projects as needed.

While the culture among the campus research faculty has not been focused on commercialization of research, the prospect of commercialization is starting to come up more and more often in conversations among faculty and students. The formal entrepreneurial graduate classes have provided those students with the confidence to initialize these discussions, and the Office Of Entrepreneurship, with assistance from the Technology Licensing Office, plans to implement commercialization training sessions for both UA research faculty and a broader community of students. These efforts, when combined with the continuation of past efforts, should result in even more technology commercialization by UA faculty and staff in the future.

Summary:

In this paper, we have discussed the evolution of STEM graduate entrepreneurial education at the University of Arkansas from a single research commercialization course to a full Graduate Certificate in Entrepreneurship. We have addressed the formation and management of interdisciplinary entrepreneurial teams, the factors leading to the teams' successes in business plan competitions, and how the teams have moved from student business plan competitors to start-up owners.

We are optimistic about the role these teams, and future ones like them, will play in the economic development of our state. Support for our entrepreneurship activities have increased with the students' successes, with the central administrators above the college deans being very active in their public recognition of the achievements of student-led companies' entrepreneurial successes. This "virtuous circle" of success followed by public recognition is matched by the university's new Chancellor's concentrated effort to strengthen the university's economic development focus and activities. He has recently reorganized the Provost's office, creating new positions of Vice-Provost for Research and Economic Development and Associate Vice-Provost for Entrepreneurship. Increased central administration attention to this economic development is likely to result in institutional changes, such as the inclusion of commercialization activities in promotion and tenure decisions. By recognizing faculty members' commercialization efforts, faculty will be more motivated to routinely examine their work for commercialization potential and to encourage their students to participate in educational experiences like the Graduate Certificate in Entrepreneurship. As these efforts expand, students, faculty, the university, and the state will all benefit.