EFFECTIVE ENTREPRENEURIAL EDUCATION: A FRAMEWORK FOR INNOVATION AND IMPLEMENTATION

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ABSTRACT

The misalignment between higher learning practices in relation to teaching technical entrepreneurship, and the needs of high-tech start-ups and existing technology-based businesses is substantial. This article provides an innovative approach to remedy this problem. The approach advocated in this article stresses an open system orientation with external strategic partners in business, industry, the professional community and technology-based business incubators. The suggested approach has been applied with substantial benefits for both higher education and external stakeholders. Results of three mini-case studies utilizing the advocated approach are presented and their implications are discussed.

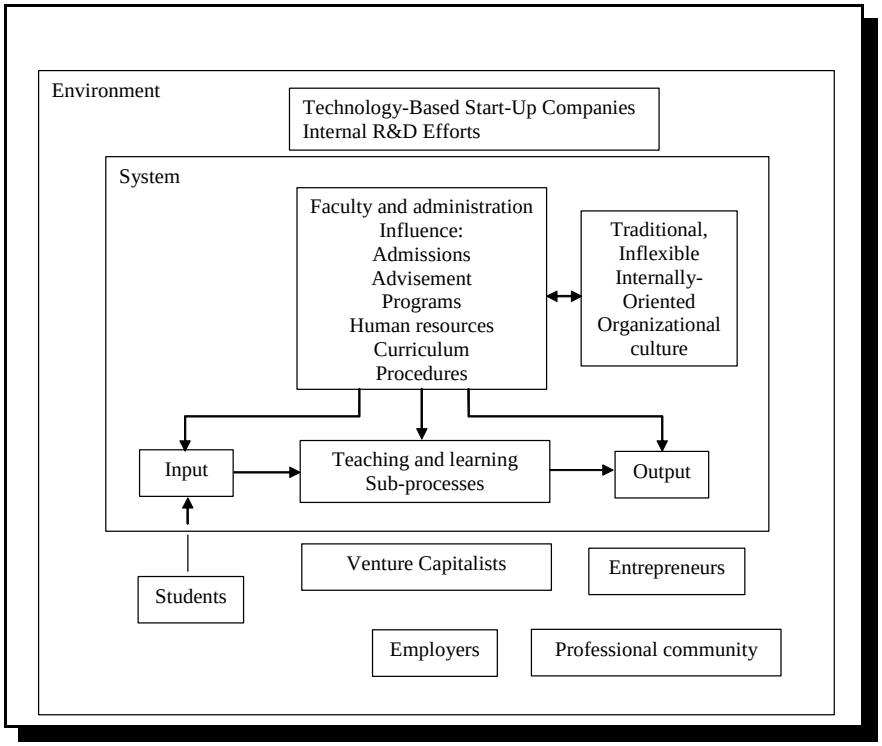
INTRODUCTION

It is difficult to be optimistic in these turbulent times. Headlines in the popular press tell us that investors are loosing confidence in CEO's, the Bear market is causing huge losses in retirement portfolios, and stock markets are unlikely to recover until the fourth quarter of 2004. Against this backdrop, innovative entrepreneurship education may offer a glimmer of hope, as it has the potential to positively influence both new business start-ups and new business development within existing businesses. However, in order for such potential to be translated into a tangible economic positive force, higher education must adopt an open system approach that stresses technical innovation and partnerships with the businesses, industries and professional communities responsible for commercializing these innovations.

In general, institutions of higher learning have been slow in responding to the new realities of technical entrepreneurship education that is founded on web-based information technology in a global business context. Not unlike business organizations of the recent past, many of these institutions of higher learning still operate under the closed system orientation illustrated in Figure 1. In this context, they are slow to provide the skills needed by a technology-based business start-ups and the internal research and development (R&D) requirements of existing technology companies. According to Calabree (1993) rigidity and the dysfunctional nature of the higher learning culture and practices makes change difficult. However, higher education can learn from

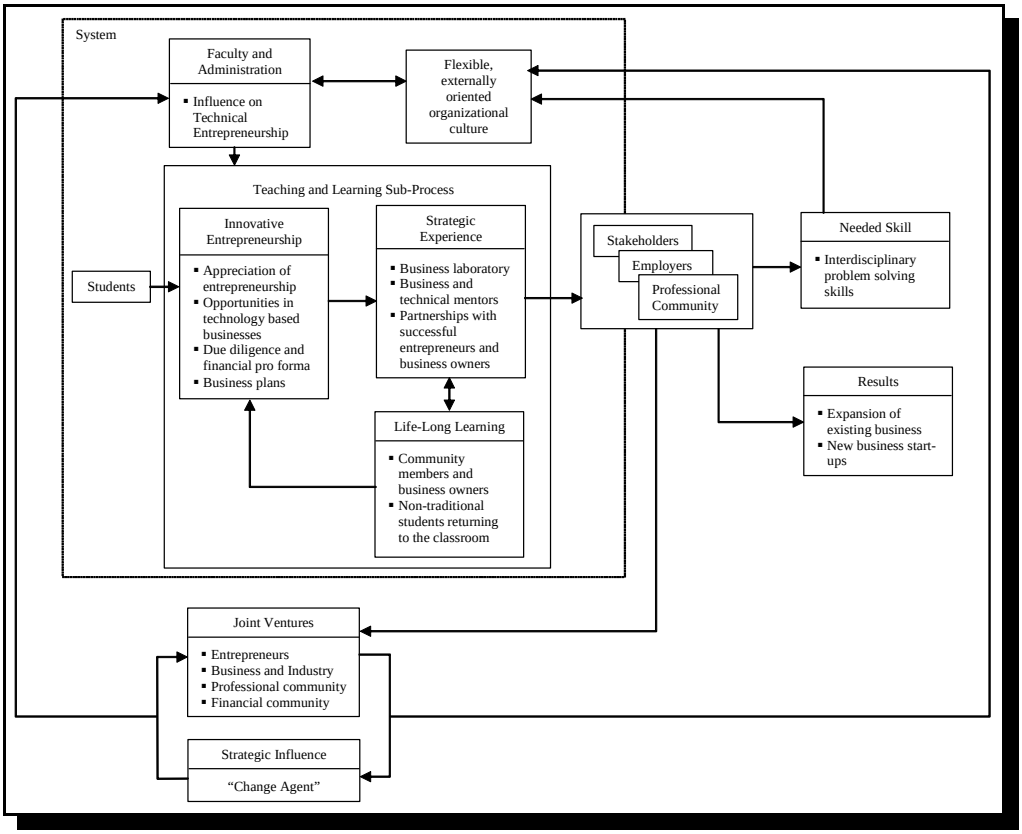
the business environment that is constantly changing and competing in a global environment that requires flexibility and innovation in order to respond to customer needs and expectations. Flexibility is a competitive dimension that helps organizations respond to environmental uncertainty and change (Butler & Ewald, 2000). Few institutions of higher learning have moved to the open system stage characterized by an increased outward orientation with a focus on appropriate stakeholders. In the context of technical or innovative entrepreneurship education, these stakeholders become employers in existing technology-based businesses, practicing entrepreneurs, students, and the financial and professional communities.

Figure 1: Traditional Framework Of Teaching And Learning: A Closed System Orientation With No Stakeholder Influence



The objective of this research is to address the need for higher learning institutions teaching entrepreneurship to rethink their mission, strategies and operations to make them more consistent with the open system orientation practiced by businesses today. In the process, mutually beneficial partnerships between business, business incubators and new technology-based businesses are suggested as a step in that direction. The second step involves initiating a process for continuously augmenting the practitioner's skill-set by delivering relevant courses in a timely manner. With these two steps in mind, a framework for implementation is suggested in Figure 2. This framework provides the backdrop for the East Tennessee State University (ETSU) experience that is briefly discussed to shed some light on a practical implementation path that others may benchmark.

Figure 2: Strategic Influence-Conceptual Model: An Open System Approach To Technical Entrepreneurship Education



One contribution made by this study is the conceptual model that provides a context in which higher education can respond to the growing need for systematic technical entrepreneurship education, bridging the gap between the practice of effective entrepreneurship and the skills needed to be successful. This model advocates open and complete collaboration between business, industry, the professional community, and technology based business incubators. The academic and business community recognizes the need for such collaboration. Three mini case studies are presented that demonstrate some of the benefits resulting from the suggested open system model. From the university perspective three patents were acquired from a major chemical company, a separate not for profit research foundation was formed to help mitigate the risks associated with biotechnology ventures, technology transfer was improved, and a new market for our technical entrepreneurship program within existing businesses was identified. This latter opportunity occurred because our partners recognized the those responsible for new product or new business development need the same entrepreneurial skill set as those launching new ventures. In addition to public recognition for their generosity, one of our large business partners benefited from an income tax write-off for their donation of intellectual property. A medium sized business partner gained a comprehensive business plan to accelerate the commercialization of their intellectual property, and also improved

their strategic business model to use technical innovation as a means to gain a sustainable competitive advantage. One of our new venture partners received second round venture capital funding aided by the digital animation designed by our student team. The CEO of this company indicated that the digital animation provided a visual means for rapidly explaining the market benefits resulting from his complex proprietary technology. One faculty member benefited by becoming CEO of a new venture launched in our technology based business incubator and by receiving a government grant to further his commercialization efforts. Another faculty member is consulting for a start-up company in our Innovation Laboratory. During video interviews taped with the students' permission, technology students said that they acquired new business and marketing skills that help them contribute more effectively to company development projects. In addition, business students indicated that they gained a deeper appreciation and understanding of the need for cross-disciplinary teams and approaches when launching high technology business ventures. Hopefully, this article makes a positive step in helping align technical entrepreneurship education with the needs of external stakeholders so that other institutions of higher learning may enjoy similar benefits.

BACKGROUND

Until the late 1970s, higher education and R&D groups in large technology-based companies operated in a relatively static environment. Engineers and scientists seeking breakthrough and innovation were technology-focused with little attention to commercialization or business potential. As a result, higher education adopted a closed system orientation characterized by traditional programs with separate and distinct engineering and business curriculum and offerings. Instructors, rather than drawing on their own wealth of experience, resorted to the teaching model of subject-based teaching handed down by their former professors (Wright, 1995). As a result, very few cross-disciplinary practical-technical entrepreneurship programs emerged. Furthermore, engineering management courses focused on managing technical projects. Although cost and schedule parameters were adequately addressed, the technical performance impacts on market potential, manufacturing risks and Federal Drug Administration (FDA) or other regulatory barriers to successful commercialization were often ignored. These later issues frequently were the very ones that determined overall project success in terms of business measures such as return on investment (ROI).

As a consequence, programs often produced MBA graduates with little appreciation of technical innovation and Masters of Science graduates in Engineering or Engineering Technology with little business acumen. During this same timeframe, smaller more agile entrepreneurial efforts grew into larger technology-based businesses forcing both business leaders and educators to reconsider the need for enhanced technical entrepreneurship skills. One of the gaps identified in the literature was that little attention was devoted to the development of teamwork, communication, and practical managerial skills (Coleman, 1996). Yet, these were the skills being demanded by the business community (Haffner & Maleyeff, 1995).

Significant steps have been taken to address the inconsistencies between business demands and business education. Lehigh and others have created cross-disciplinary programs to enhance a student's entrepreneurial skills by blending engineering, business, design, and other sciences (Ochs et al, 2001). Although a consensus on the content for programs of study has not been reached, a curriculum with at least one course covering the essentials of starting a business including writing a business plan, plus additional course work in small business management, negotiation, high technology, or global business appears to be a reasonable baseline (Kautz, 2000). However, it should be noted that an entrepreneurial leadership program is also important to medium and large sized businesses that rely on new product development and growth to achieve their strategic objectives. Of the current programs in entrepreneurship offered by top schools in business and engineering identified by US News and World Report as of April 2002, only three (3) colleges have graduate certificates in entrepreneurship: University of Chicago, University of California - Berkeley, and Georgia Institute of Technology. Others have majors, minors, or concentrations in entrepreneurship. The "Compendium of Entrepreneurship Programs" by Vesper and Garner identifies one-hundred-and-twenty-four (124) colleges that offer three (3) or more classes on entrepreneurship. Of the one-hundred-and-twenty-four (124) colleges, only ten (10) have certificates in entrepreneurship. The teaching methods utilized tend to vary as illustrated in Table 1.

Table 1: Teaching Methods

College	Lecture	Case Study	Other
Pennsylvania	55%	30%	15% experiential learning
Northwestern (Kellogg)	33%	33%	34% team projects
Harvard	15%	75%	10% simulation, field studies
MIT (Sloan)	30%	45%	25%
Duke	45%	40%	15% simulation
Michigan	40%	40%	20% experiential Learning
Columbia	40%	40%	20% group projects
Cornell	25%	40%	35% Discuss., projects
Chicago	50%	25%	25% lab simulation

The need for real-world experience is stressed by the use of the case study method, experiential learning, and simulation approaches as shown in Table 1. However, a path toward achieving the open system orientation still appears to be lacking. In order to shed some light on this pathway, a strategic influence-conceptual model providing an open system approach to technical entrepreneurship education is suggested in Figure 2. This model encourages the free flow of information between the external stakeholders, comprised of those who employ our graduates and the professional community, to influence the technical entrepreneurship curriculum to better match

the skills needed for success in the practical environment. One suggested strategy is to form joint ventures and mutually beneficial partnerships to strategically influence entrepreneurship programs and their teaching and learning sub-process. In addition, the suggested teaching and learning sub-process underscores the students' need for practical experience that can be gained through partnerships with successful entrepreneurs, business owners, and technical business incubators. Students develop business plans that link innovative technologies to the marketplace, while partners serve as business and technical mentors. The arrangement is mutually beneficial as students gain the needed practical experience, and business partners benefit from the outside perspective provided by the students and instructors.

Another important attribute highlighted in the conceptual model is the community's need for lifelong learning in order to maintain a competitive advantage. This is particularly true in high technology organizations where the pace of change of technology mandates the need for innovation. The cultural impact on the faculty and administration is that non-traditional students must be accommodated. One strategy is to offer graduate certificate programs in entrepreneurship that focus on updating skill sets, without requiring a full master's curriculum. An example of such a graduate certificate program is given in Exhibit 1.

Exhibit 1: Courses For Certificate In Entrepreneurial Leadership

Core Courses	Credits
Small Business Management	3
Entrepreneurial Finance	3
Innovative Entrepreneurship	3
Strategic Management of Technology and Innovation	3
Strategic Experience or Entrepreneurial Experience	3
Electives	Credits
Students pick one of the following courses.	
Leading Continuous Improvement	3
Leading Empowered Problem Solving Teams	3
Scheduling for Project and Quality Management or Project Management	3

During the past eleven years ETSU has been developing partnerships with business, industry and the professional community to enhance our program in innovative entrepreneurship. By innovative entrepreneurship we mean creatively using technology to generate new business opportunities. During this period a stream of research was conducted to suggest best practices in teaching technical entrepreneurship. Our research and the practical experience gained in implementing our program suggest that the open system and partnership approach shown in Figure

2 results in significant benefits for the students, faculty, staff and strategic partners. Some of these benefits were highlighted earlier in this article. The purpose of the discussion below is to provide further detail on the most important lessons learned during this process.

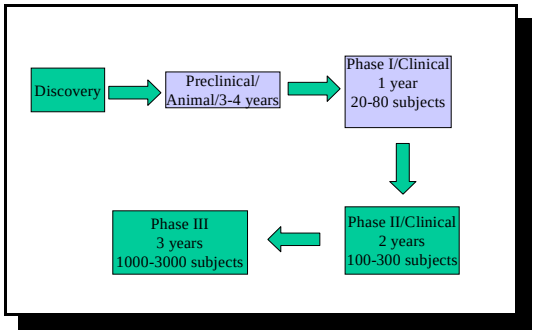
One of the significant lessons learned from the ETSU experience and benchmarking exercises with other universities having affiliated business incubators, is that few institutions of higher learning have a systematic approach for commercializing the intellectual property that results from their faculty's research. Intellectual capital often lies dormant in the university setting. Furthermore, faculty and staff frequently believe that commercializing this intellectual knowledge would be of substantial benefit to themselves and to their students who would experience the entrepreneurial process first hand. The first mini-case study outlined briefly below stresses how the framework in Figure 2 can assist in realizing these benefits.

Over a period of several years, one of our faculty members conducted sustained research on cholesterol lowering drugs and in conjunction with a major chemical company obtained a patent. However, the patent remained dormant because the pathway to commercialization involved several years of pre-clinical work with animal models and then extensive clinical trials. Since the company involved did not have an estimate for the commercial value of this patent, management elected not to make the economic investment necessary to move forward.

Guided by the framework in Figure 2 a student project was designed and implemented. The first author on this article and an outside expert in biotechnology business start-up ventures served as business mentors and the faculty member holding the patent served as a technical mentor. A graduate student team comprised of a Medical Doctor, a Ph.D. candidate in Biotechnology and a MBA candidate took the Innovative Entrepreneurship course as a first step in the Teaching and Learning Sub-process. This cross-functional team generated a comprehensive business plan that quantified the potential economic benefits of the drug when commercialized, and laid out the pathway and timeframe required for success. As part of this first step in the Teaching and Learning sub-process, the graduate student team, guided by the business and technology mentors, developed a more comprehensive business model for the new business venture that subsequently emerged (See Figure 3).

Although the patent had previously been stagnant, the business model for this new biotechnology company's niche in the patent development chain created a business opportunity for the faculty member who had developed the intellectual property. Strategically this new venture strives to commercialize biotechnical intellectual property for nutraceuticals, pharmaceutical or medical devices. Their business model suggested that as research scientists, a faculty team could use their core competencies, to evaluate the efficacy of a product by conducting pre-clinical work with animal models and then extending their efforts to clinical trials. Success with each phase of clinical testing increases the commercial value of the patent. Once sufficient value is demonstrated, the new biotechnology venture plans to out-license this proven capability to an interested buyer. Their future customers will be large pharmaceutical or medical companies with the necessary capital to market and manufacture new products worldwide.

Figure 3: Simplified Business Model For Biotechnology Company's Niche In The Patent Development Value Chain



Guided by the framework shown in Figure 2, the researchers were able to approach the major chemical company holding the patent with a comprehensive business plan. Having quantified the commercial value of the patent and the pathway to success, a potential joint venture between the university and this company was explored from a mutually beneficial viewpoint. Moving through the strategic experience portion of the Teaching and Learning sub-process, it was discovered that medical and biotechnology students were consumed by their commitments on other research projects in their major concentration of study. As a result, they could not devote sufficient time to this particular entrepreneurial project. When the time pressures of the new business venture conflicted with other learning objectives, the cross-functional team became dysfunctional. However, detailed discussions with the students, video taped with their permission, revealed that they felt they had benefited by experiencing the entrepreneurial process. This mini case suggests that in order to make the full commitment for transition to the biotechnology business incubator, the students must have a strong technical and economic motivator. The faculty member who was co-holder of the patent with the major chemical company subsequently became the driving force for this project. When the chemical company donated this patent and two others to the university as discussed below, the faculty member became CEO for the new business venture launched in our high technology business incubator. The students continued their academic pursuits. From a teaching and learning perspective, the major lesson learned was that students most often will abandon the business venture at the end of the formal entrepreneurship class, unless they have a substantial stake in the resulting venture. Other research efforts in conjunction with the Center for Entrepreneurial Growth at the Oak Ridge National Laboratories appear to confirm these findings.

The framework shown in Figure 2 was helpful in conducting negotiations with the major chemical company for ownership of the intellectual property. Initially the possibility of a joint venture or strategic alliance was considered. Assisted by the business model and financial data, alternatives were explored for commercializing the initial patent plus two other patents held by the firm. Using a win-win negotiations approach, a mutually beneficial outcome was realized. Having quantified the economic potential and pathway to commercialization was an essential factor in

coming to closure and underscores the need for a detailed due diligence step in the process shown in Figure 2.

Recognizing that several years of continuous research were required to realize a commercially viable product, the major chemical company elected to donate the patent in question, plus two additional related patents, to the university. These two related patents were identified through the business model that emerged from the Innovative Entrepreneurship block in the Teaching and Learning sub-process shown in Figure 2. The company benefited not only because of their community service to the university, but also because the well-documented business plan demonstrated the commitment by the university to commercialize the intellectual property and also provided a solid estimate of the economic value of the intellectual property that was donated. These latter facts allowed the company to gain a tax advantage through their generosity to the university. The university benefited because this was the first case of receiving a donation of intellectual property from an external partner. This example suggests that the open system and partnership approach described in Figure 2 is mutually beneficial to institutions of higher learning and their external business partners.

Currently, this new biotechnology company has refined their business plan, is accepting shared ownership of the three patents with the university, has transitioned into ETSU's business incubator and has received a government grant to continue the commercialization process. Another benefit to the University is that the framework (see Figure 2) provides a roadmap for other faculty members to follow in commercializing their patents.

Referring again to the Teaching and Learning sub-process (see Figure 2) a teaching objective of the Innovative Entrepreneurship block is to have both business and technology students enhance their creative thought process in generating new ways to use technology to spawn new business value propositions that customers are willing to purchase. From a teaching perspective this is often the most challenging step. Our experience suggests that humor, metaphor, and art provide a means for students to unlock their creativity. Psychologists and artists (Betty Edwards, Drawing on the Right Side of Your Brain) indicate that these non-technical disciplines help students experience the difference between linear sequential thinking (left-brain processes) and synthesis skills (right-brain processes). Our practical experience with this approach suggests that students experience accelerated learning and are able to rapidly generate innovative concepts that have commercial value when aided by humor, metaphor, and artistic approaches to technical problem solving.

These innovations ultimately result in new business ventures that are launched in a business incubator (business start up facility) or they may result in new product development and marketing efforts for existing businesses. This latter point is significant because one of our discoveries in teaching innovative entrepreneurship is that these skills are also vitally important to those responsible for business development within existing businesses. From an economic development perspective this is significant because seventy-five percent of new jobs are created by existing businesses. When developing partnerships with business, industry, and the community this benefit is a significant factor in obtaining support for the university's efforts and in attracting students for our programs in entrepreneurship. When coupled with web-based or distance learning technologies, entrepreneurship education can be delivered to students on-site in existing businesses. The ETSU

experience suggests that this approach significantly expands the university's market for these courses and programs.

Most large technology-based firms have a well established new business development function. However, most small to medium sized high technology firms lack the resources to fully implement this capability. This next mini-case study involves a small manufacturing company in business for twenty-five years in a specific market niche. Through their strategic thinking process this company discovered that they could not realize their growth objectives solely in their current markets. Guided by the framework in Figure 2 the first author of this article worked with the company to define a project for one of their chemical engineers taking ETSU's course in Innovative Entrepreneurship. The importance of involving company management using the open system concept shown in Figure 2 is underscored. This early and frequent engagement of the management team ensures that the technical student in the existing business gains access to needed marketing and financial information in a timely manner.

In this situation the chemical engineering graduate student, with little business experience, was able to search through the company's intellectual property seeking potential new products or new product applications. Similar to the biotechnology patent cited in the earlier example, the student found a patent that was dormant because the business case had not been adequately developed and management lacked the information necessary to make the strategic investment decision. During the Innovative Entrepreneurship step in the Teaching and Learning sub-process the chemical engineer was able to assemble a team comprised of company employees with marketing and financial analysis skills. From a teaching perspective the lesson learned was that project contributors need not be formally taking the entrepreneurship course as long as they are committed to provide timely access to needed information. However, care must be taken to outline the student's responsibilities and the company's commitments prior to launching the project. Often a letter of engagement between the company and the university is helpful. In this letter the students document their understanding of the project scope, timeframe, and deliverables and the company commits to provide timely access to needed information and also to provide timely review and feedback for corrective action during the project.

In the mini-case just described several benefits resulted for both the company and the student. During post-course interviews, the student stated that he gained a much deeper appreciation for the business dimension of R&D efforts. He emphasized specific learning outcomes in both marketing and financial dimensions of the project. The company was delighted because the business plan provided financial and marketing information needed to link the R&D effort to its commercial value with the corresponding ROI. In addition, strategies for making this innovation a value added relationship market rather than a commodity business were cited as being especially attractive. Since the company is in the process of transforming itself from a niche market to a solutions oriented technology driven company, the check-list created by the business plan resulting from the Innovative Entrepreneurship course will be used to validate business cases for other new business innovations. This was cited by the company as a major benefit resulting from the course.

From the specific example cited above and through practical experience working with small and medium sized manufacturing businesses, another teaching and learning lesson is also apparent. The R&D process to create new products spans a time period longer than one semester. Therefore,

in order for the existing technology based business to realize the expansion of business results suggested in Figure 2 one of two alternatives should be considered. Either existing intellectual property should be required as the input to the Teaching and Learning sub-system, or the entrepreneurship program in partnership with existing businesses should span up to four semesters to cover the R&D discovery and innovation process.

The final mini-case for this article illustrates two additional lessons learned. In partnership with the Center for Entrepreneurial Growth (CEG) at the Oak Ridge National Laboratories (ORNL), ETSU established three cross-disciplinary graduate student teams to work with start-up companies. The CEG is a business incubator designed to transfer technologies created by the ORNL into the commercial sector. Twenty-Six new business start-up companies are currently in the CEG. The primary lessons learned through this partnership are twofold. Since these CEG companies are high-tech based, they often are led by highly specialized scientists and engineers. Graduate student teams with technical marketing experience can often make significant contributions within the semester long Strategic Experience course. The students gain first-hand entrepreneurial experience by living and working with the fledgling technology based start-ups, and the companies benefit from the strengthened competitive and marketing analysis that results from the strategic project. In addition, graduate students with non-directly related technology experience, not having had the course in Innovative Entrepreneurship, can participate in the Strategic Experience. Often the high-technology companies are seeking venture capital and have difficulty in explaining the commercial value of their inventions to their financial backers. Digital media students, through graphical animation, can often capture the salient features of the technical innovation in a readily understandable format for venture capitalists and other investors. The outcome of this partnership is that the digital media graduate students experience high-tech entrepreneurship first hand, while the digital animations produced provide the high-tech start-ups with help in raising venture capital.

The three mini-case studies discussed in this article illustrate specific benefits that have resulted from application of the open system framework shown in Figure 2. These benefits are summarized briefly below from the university, community/partner, and faculty/student perspectives. From the university perspective the formation of the biotechnology company resulted in the donation of three patents from the chemical company, creation of a separate not for profit research foundation to accept this donation, improved commercialization of intellectual property that would have otherwise been dormant, and a practical roadmap for other faculty to follow in the transfer of their technology to potential commercial markets. In the future the university could receive royalties, should the venture become profitable. For ETSU these were all firsts. From the partner's perspective, the major chemical company received recognition for their generosity, an income tax write-off, and helpful input to their internal innovation business model as they implemented their corporate venture group. Biotechnology faculty and students gained an appreciation and understanding of the business dimension of technical entrepreneurship. The faculty member also benefitted by becoming CEO of the new venture and by receiving a government grant to further the commercialization of the intellectual property.

In the case of the small manufacturing firm, the university gained a market for their technical entrepreneurship program within existing businesses and also found business mentors willing to help other student teams. This suggests practical steps that can be taken in working with other small to

medium size manufacturing firms within the region served by the university. From the company's perspective a comprehensive business plan was developed to accelerate the commercialization of their existing intellectual property. More importantly, the company was able to refine their business model to aid in their transformation to a more technically innovative organization. The engineering student gained new business and marketing skills that he claims help him contribute more effectively to other company development projects.

One of the start-up companies in the Center for Entrepreneurial Growth received second round venture capital funding. According to the CEO the digital animation was helpful in explaining a complex technology to his financial backers. In addition, the strategic marketing audit provided some value by helping refine the competitive analysis and market niche. The Oak Ridge National Laboratories, as part of a broader partnership effort with the university, makes more than 90 patents available to student teams pursuing technical entrepreneurship studies. This is another first for ETSU. In addition, following the practical approach suggested in this article, faculty are finding consulting opportunities with start-up companies within the ETSU Innovation Laboratory (technical business incubator).

In summary, the framework shown in Figure 2 has served as a useful guide in implementing an open-system-partnership approach to technical entrepreneurship education at ETSU. Students, faculty, staff, the university and our strategic partners have all benefited as discussed above. Guided by the framework, the university is also able to contribute to its objective to promote economic development, because our technical entrepreneurship education has a natural result of creating new technology based start-ups as well a promoting new product and business development for existing firms. We are currently expanding our horizons to include an international dimension. In partnership with the Hochschule Bremen (HB), ETSU is further refining our program to offer a Graduate Certificate in International Entrepreneurship. The major additions include inter-cultural business and team training, an appreciation and understanding of the requirements for global technology based companies, and a mandatory summer session abroad. This term abroad may include a Strategic Experience in either the ETSU or HB Business Incubator. To accomplish this learning objective we introduce the concept of twinned incubators. By twinned incubators we mean that certain new technology business may be better launched in European or in US markets; and the appropriate incubator for the new venture is chosen based upon the market it will initially serve. This approach takes the open system framework shown in Figure 2 to an international application.

A PROPOSED OPEN SYSTEM APPROACH

Although significant strides have been made, the closed system approach that is still present in many higher learning institutions teaching innovative entrepreneurship falls short of stakeholder needs and expectations. In this context, the stakeholders include technology based start-up companies, R&D organizations within existing technology-based businesses, the financial and professional communities, and the students served by the learning institutions. The transition to an open system orientation should be guided by the dominant strengths and business opportunities faced by many technology-based start-up companies and R&D organizations within existing

technology-based businesses. Toward that end, Exhibit 2 suggests that improvements require an infusion of business skills to link technical innovations to commercial market business results. Coupling this with the need for real-world entrepreneurial experience underscored in the literature cited above, the teaching and learning sub-process in Figure 2 results. This sub-process is comprised of three main functions: 1) Learning in innovative entrepreneurship; 2) A real-world strategic experience in entrepreneurial practices; and 3) Opportunity for life-long learning with non-traditional students returning to the classroom with the purpose of enhancing their technical entrepreneurship skills.

The innovative entrepreneurship learning experience brings engineering and business students and faculty together in cross-disciplinary teams. These teams start with an innovative technology that must be commercialized. Through the due diligence process the commercial value of the innovation is determined and the market potential and corresponding financial performance are described in a formal business plan. An important lesson learned in this teaching step is that partnerships with business, industry and the community create opportunities to bring bankers, successful entrepreneurs and small business owners, venture capitalists, and other resource people into the classroom. Furthermore, these partners often act as business and technical mentors and provide helpful guidance to refine technical innovations and business concepts. From these real-world experiences students learn lessons that no textbook could provide.

The final product of the innovative entrepreneurship learning experience is a business plan that is reviewed by a panel of experts. With helpful suggestions from this panel the students proceed to the Strategic Experience. (See Figure 2.) This experience is conducted in a living business laboratory (business incubator or start-up facility) or in an existing business. As Starzynski (2000) attests, a center with an incubator provides a nurturing environment for young companies. Benefits in having an incubator affiliated with the university include the availability of shared facilities, the opportunity for scientific collaboration, and access to a larger and more highly skilled work force pool (Mazur, 2001). From the teaching and learning perspective, the incubator provides a living laboratory where students can validate innovative business concepts before making the ultimate commitment of financial resources to the actual business venture. For technical environments, one may decide to include a shop and a fabrication lab in the facility as Lehigh has in their center (Ochs et al, 2001). However, most universities do not have the financial resources to provide access to complex laboratory and manufacturing equipment. Whereas existing business and government laboratories have already made these financial investments to accomplish their objectives. Here the strategy of mutually beneficial partnerships and joint ventures has a major strategic influence on the outcomes as suggested in Figure 2. The ETSU's partnerships-based experience with Oak Ridge National Laboratories; local businesses such as Eastman Chemical, Siemens, Sprint, AFG Industries and Amerace; and local hospitals and health care organizations has provided real-world opportunities for our students in entrepreneurship.

The importance of life-long learning opportunities for community members is underscored in the Teaching and Learning sub-process. With the rapid pace of change of technology and the challenges of global competitiveness, the need for enhanced skills becomes a requirement for technology-based businesses to survive. Physicians, and other advanced degree holders also need these skills. However, they encounter barriers when approaching institutions of higher learning

because they cannot afford the time commitments to gain another full graduate degree. One strategy for overcoming this difficulty is to offer a graduate certificate program delivered on-site to the existing business' facility. In ETSU's situation our Innovation Laboratory has implemented a virtual incubator through the use of web-based information technology. This same technology creates an electronic boardroom environment where business plans and concepts can be reviewed with students worldwide.

Exhibit 2: Characteristics Of Technology Based Start-Up Companies And R&D Organizations

Characteristics of Technology Based Start-Up Companies		
1.	Strengths	
	a.	Strong scientific knowledge and know-how
	b.	Proprietary technology and intellectual property often protected with a patent
	c.	Laboratory technical knowledge of the application
2.	Improvement Opportunities	
	a.	Business acumen often underdeveloped
	b.	Little marketing expertise
	c.	Under appreciation of the commercialization process
Characteristics of Many Research and Development (R&D) Organizations		
1.	Strengths	
	a.	Detailed knowledge of the science and technology
	b.	Passion for the technical discipline
	c.	Experience with the laboratory test and validation processes and procedures
2.	Improvement Opportunities	
	a.	Little understanding of the commercialization process
	b.	Unable to determine the commercial value of the technology or the R&D effort
	c.	Little customer interaction to determine the value proposition the technology represents

GRADUATE CERTIFICATE PROGRAM IN ENTREPRENEURIAL LEADERSHIP

The ETSU graduate certificate program in entrepreneurial leadership is structured to implement the open-system-partnership approach illustrated in Figure 2. The program is comprised of five core courses and one elective (See Exhibit 1).

CONCLUDING REMARKS

The closed system traditional framework for teaching entrepreneurship with separate and distinct engineering and business curriculum may have provided satisfactory results when business and industry were relatively static. However, the rapidly changing global competitive environment faced by most high-tech businesses today has created a misalignment between technical entrepreneurship education and stakeholders that seek to benefit from such education. Flexibility is a competitive dimension that an organization can utilize to respond to environmental uncertainty and change(Butler & Ewald, 2000). However, to capitalize on this flexibility, cross-disciplinary skills appear to be essential.

Entrepreneurship education has transitioned through three distinct phases over the past 40 years. A closed system traditional orientation presented in Figure 1 is deeply influenced by teaching culture rather than the technical and business needs of agile high-tech firms and other stakeholders. Stage two represents a step between the closed and open system orientations. During this stage limited cross-disciplinary activities between business and engineering courses provided some benefit to external stakeholders. In response to the high-tech business needs for innovation, agility and flexibility the authors advocate an open-system partnership approach given by the conceptual model for technical entrepreneurship education in Figure 2. For ETSU, this approach has resulted in substantial benefits for students, faculty, and start-up ventures, the professional community, and existing business and industry.

Guided by this framework, a systematic strategically effective approach for commercializing previously dormant intellectual knowledge can be implemented to benefit the university, the faculty and students, and the university's strategic community partners. Once the potential commercial value of the intellectual property and the pathway to success is quantified through the due diligence process, potential joint ventures between the university and external stakeholders are possible. In the ETSU experience, this led to the transfer of ownership of three patents from a major chemical company to the university and a faculty led biotechnology venture.

A significant lesson learned in implementing the framework shown in Figure 2 was that innovative entrepreneurship skills are also vitally important to those responsible for business development within existing businesses. This is significant because seventy-five percent of new jobs are created by existing businesses. In this context, technical entrepreneurship education contributes to economic development along two dimensions: new venture creation and growth of existing businesses. Furthermore, this benefit is helpful in attracting students for programs in entrepreneurship. When coupled with web-based or distance learning technologies, entrepreneurship education can be delivered to students on-site in existing businesses suggesting expanded markets for entrepreneurship courses and programs. Companies stand to benefit from these innovative business developments because resulting business plans provide needed financial and marketing information to link R&D efforts to future commercial value with the corresponding ROI. This benefit is especially attractive to small to medium manufacturing and high-tech firms that lack the resources to fully implement their own new business development functions.

From a teaching and learning perspective another lesson learned was that graduate students can enter the sub-system (see Figure 2) at the Strategic Experience phase with partial benefits

resulting for the students, faculty and strategic partners. This is especially true in dealing with the high-tech companies such as those in the ORNL CEG. Small high-tech firms led by highly trained scientists and engineers benefit from the outside perspective provided by the faculty and graduate students. Although this is especially true in marketing and financial areas, technical value can be added as well. Using digital media skills, for example, graphical animation is often helpful in capturing the salient features of the technical innovation in a readily understandable format for venture capitalists and other investors. The outcome of partnership with high-tech start-ups is often that the students experience high-tech entrepreneurship first hand, while the high-tech start-up gains help in raising venture capital.

In summary, the authors advocate the framework shown in Figure 2 as a guide in implementing technical entrepreneurship education. The ETSU experience suggests that students, faculty, staff, the institutions of higher learning's strategic partners will benefit from this approach. The university has received three patents, formed of a separate not for profit research foundation, improved technology transfer, and gained a market for our technical entrepreneurship program within existing businesses. Our existing business partners have benefited from an income tax write-off from their donations, business plans to accelerate the commercialization of their intellectual property, and refinements to their business models using technical innovation to gain a sustainable competitive advantage in their markets. A start-up partner received second round venture capital funding aided by the digital animation designed by our student team. A faculty member benefited by becoming CEO of a new venture and by receiving a government grant to further his commercialization efforts. Another faculty member is consulting for a start-up company in our Innovation Laboratory. Technology students gain new business and marketing skills that help them contribute more effectively to company development projects. Hopefully, this article makes a positive step in helping align technical entrepreneurship education with the needs of external stakeholders and suggest lessons learned and approaches that might be helpful should others choose a similar pathway.

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