

AC 2007-1950: ENGINEERING ENTREPRENEURSHIP EDUCATIONAL EXPERIENCE (E4) INITIATIVE: A NEW MODEL FOR SUCCESS

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Engineering Entrepreneurship Educational Experience (E4) Initiative: A New Model for Success

Abstract

Recognizing the effect of entrepreneurial activities on student motivation and excitement, the Electronics and Telecommunications Engineering Technology (EET/TET) Programs at Texas A&M University have begun a unique initiative in the area of entrepreneurship. The Engineering Entrepreneurship Education Experience (E4) model brings entrepreneurship from the private sector into the undergraduate environment. It begins with the idea/concept process. At brainstorming sessions with private industry, faculty, and beginning capstone students, new ideas for products and systems are identified for development. Student teams select ideas that have strong industry support, and through two semesters of planning and implementation transform them into fully functional prototypes. At the end of the second semester, the E4 student teams deliver a combined technical/business/marketing presentation to invited private sector and business development representatives. Selected projects may follow one of two paths: the new venture path (regional start-ups) or the technology transfer path (licenses).

The most promising products/systems take the new venture path, and the student developers who have now graduated are offered the opportunity to continue in the development of a new business through an undergraduate-dedicated technology incubator located at Texas A&M University. To develop and grow its business, each company receives one full year of support in the incubator. After this, the company leaves the incubator and local economic development councils work with these start-up businesses by offering incentives to keep them in local area .

If the project is not selected for incubator support, the student team may follow the technology transfer path. In this case, the University will work as the agent for the inventors (students and faculty), and negotiate with interested companies to license and transition the product know-how to the private sector for production and commercialization. This paper will discuss the new E4 model and present specific examples of student success.

Introduction

Motivation. At the 2006 ASEE National Conference, the authors briefed the ETD Division on a conceptual initiative on entrepreneurship. Since then, much progress has been made. This paper details the Engineering Entrepreneurship Educational Experience (E4) Initiative and describes current progress, E4 successes, and future directions.

The EET/TET Programs faculty established the Mobile Integrated Solutions Laboratory (MISL) in 2002 to enhance the senior project design experience for the undergraduate students. The single semester, “works once” project model typically employed in academia was expanded to a two-semester sequence for project planning¹ and project execution.^{2,3} This resulted in three key benefits to the curriculum. First, because the students were given an additional semester to complete their project, the faculty noticed a significant increase in the quantity and quality of effort by the students. Second, this increase in quality has resulted in more interest in the design

and innovation process by the EET/TET faculty. Before the change, one faculty member was typically responsible for coordinating all student projects. With an enrollment of about 200 students, this meant that a single faculty member was responsible for overseeing about five to twelve projects each semester. Now, most of the faculty share responsibility of advising and working with student teams. Finally, increased participation by the faculty has resulted in more interest and involvement from other departments and the private sector.

Since 2002, the undergraduate process in the EET/TET Programs has been refined so students entering their senior year of coursework are expected to:

- Form a team that will function as a start-up venture;
- Develop a new product idea;
- Identify sponsorship and secure a technical advisor;
- Plan their design and development efforts using the principles of project management;
- Execute and control the design and development of a prototype and associated design package; and
- Conduct a marketing presentation for commercialization.

With these enhancements, this course sequence no longer generates just a breadboard version of a “works-once” design. Through support of the sponsor and guidance provided by the technical assistance team², the students are able to design, fabricate, test, and deliver a commercially viable prototype ready for beta testing. MISL provides the resources necessary to support the idea to the prototype portion of a new product development cycle.

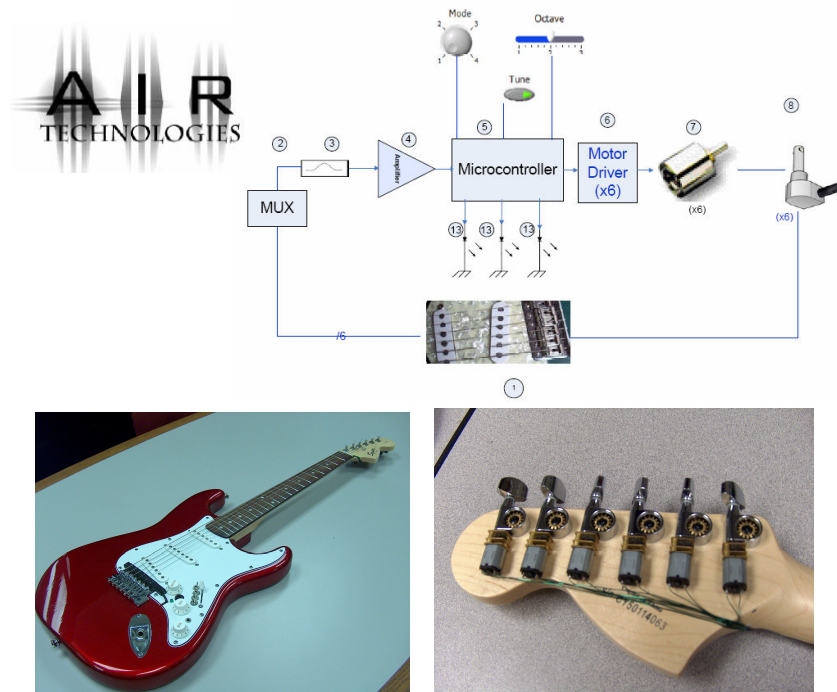


Figure 1. AutoTune.

This new process has since generated several successful projects achieved through the motivation and support of the undergraduate teams, including products for the consumer and industry markets as well as systems to be used by the private and public sectors. An example of this success is Project Autotune where a student team designed and implemented a generic retrofit system that uses motors and a microcontroller to automatically tune an electric guitar. Upon graduation, the students briefed several companies on their prototype and found interest in commercializing their idea. While all of the students involved have since taken jobs, they are working together in their spare time to meet with venture capitalists and to understand their possible next steps.

Based on successful projects such as this, the EET/TET Programs have determined that as a logical improvement to the senior project sequence, a more formal entrepreneurship initiative is needed. Imagine, as in the case above, if the students' educational program included the possibility of post-graduation support and continuing education targeted at helping the students become a viable start-up company. To pursue this concept, the authors started by looking at what other schools were doing.

Entrepreneurship in Education. Currently, the literature suggests that entrepreneurial activities in engineering education can be broadly classified into four categories. First, many schools develop curriculum and workshops designed to teach entrepreneurship. This curriculum is generally offered either directly through engineering programs or more often by business and/or management programs. In 1997, the University of Houston began a two-semester course sequence to teach engineering students entrepreneurship in a business processes approach from a CEO's perspective.⁴ At Grove City College, engineering students in the senior design course are teamed with business students and can enroll in a course on the development of business plans. Success is measured through a business plan competition.⁵ Pennsylvania State University launched the PBLE Program that allows students to receive a minor in entrepreneurship through coursework and the development of a business plan.⁶ The Electrical Engineering Department at the University of Nevada in Reno uses an interdisciplinary capstone course to teach entrepreneurship and have created a K-12 outreach program.^{7,8} Many schools offer workshops to interested individuals to promote entrepreneurial activities. An example of this is the Invention to Venture workshop developed by the NCIIA and member institutions.⁹

Second, many programs create activities that emulate entrepreneurship such as the creation of engineering and/or interdisciplinary student teams that develop product ideas, form a "company", develop prototypes, and create business plans. These teams often compete in regional and national business plan competitions. The University of Colorado at Boulder has previously published a one semester design course where the students design and build a product and do a feasibility analysis for commercialization. This program has been supported by the NCIIA.^{10,11} The EPICS program started at Purdue teams engineering and business students with community organizations to solve technical problems. Teams are also encouraged to participate in entrepreneurship competitions.¹² At Cooper Union, local engineering entrepreneurs are used to teach a course to student teams which then prepare a business plan for a new venture.¹³ Rowan University promotes entrepreneurial activities in their design clinics using a venture capital fund created by grants from the NCIIA. Interdisciplinary student teams can compete for these funds.¹⁴

Third, internships are offered that place students in an entrepreneurial environment external to their educational program. This includes small start-up companies and regional new venture incubators. East Tennessee State University suggests that one mechanism for fostering entrepreneurship in students is to allow them to work for and consult at regional and university incubators on other people's projects.¹⁵ At Brown University, an NSF sponsored project pairs engineering students with "parent companies" local to the region that sponsor a two-semester project and can elect to help successful teams go to the next level in terms of commercialization. The Technical University of Moldova piloted an entrepreneurship program in 2003. An integral part of this experience was an internship with successful local entrepreneurs.¹⁶ At Johns Hopkins, the W.P. Carey Program in Entrepreneurship and Management supports entrepreneurship through course offerings, off-campus internships, and business plan competitions.¹⁷

Fourth, Entrepreneurship Centers and on-site business accelerators/incubators are created and maintained to support university entrepreneurial activities. McCorquodale suggests that teaching entrepreneurship is not enough; making students successful requires academic and professional resources.¹⁸ To this end, several universities including Carnegie Mellon, MIT, Stanford, UIUC, and Arizona State and others have Centers and offices that focus on Entrepreneurship, teach courses, and help individuals connect with the outside world.¹⁹⁻²⁴ Many universities establish incubators on or near campus to facilitate the development of intellectual property and businesses based on faculty and graduate student innovations.²⁵ At the University of Central Florida, a three-course program in Engineering Entrepreneurship is used to give students and researchers the tools to be successful. Interested individuals can then work with the UCF Technology incubator, a facility designed to assist in the commercialization of university intellectual property. Also, in 2002, the NSF-funded program CENTECOM was put in place to proliferate UCF's activities throughout the state.²⁶ A similar program has been created at Florida Institute of Technology where interested seniors and graduate students can not only take coursework in entrepreneurship but can also apply for NCIIA funding and/or work with the University's TechStart business accelerator to commercialize their ideas.^{27,28} Current literature suggests that while many schools promote these facilities to undergraduate students as a means to pursue the commercialization of IP, this is generally a transition where the students move abruptly from an educational environment directly to a business environment. One very interesting exception to this, and part of the inspiration for this proposed model, was an informal case found at Oklahoma Christian University where a group of students interested in commercializing their senior project idea was given space in their major department and resources after graduation in exchange for university shared ownership in the idea.²⁹

While most entrepreneurship programs combine two or more of the elements above, most do not tie commercialization and new ventures directly to the student's education. More often than not, undergraduates with a viable idea have to move to an incubator that is really intended to support faculty and professional start-ups in order to continue through the entrepreneurial process. The Engineering Entrepreneurship Educational Experience (E4) Initiative seeks to combine the salient features of the above efforts into a single integrated process targeted at undergraduate students and leveraging the professional prototypes being generated by the current capstone design experience. Thus, E4 creates a unique environment that:

- Puts industry, faculty, and business/engineering students together early in process to generate ideas and identify entrepreneurial opportunities;
- Uses entrepreneurial courses and workshops generated by the Mays Business School and regional development councils to augment the education that students are currently receiving;
- Introduces students to successful regional entrepreneurs through a formal seminar and creates lasting relationships with those individuals;
- Specifically targets undergraduate students and provides physical resources including an incubator dedicated to their education and growth as entrepreneurs;
- Seeks to allow the student to be the entrepreneur from start to finish – from the idea phase all the way to the new start-up phase.
- Continuously provides technical and business expertise and resources to maximize success.

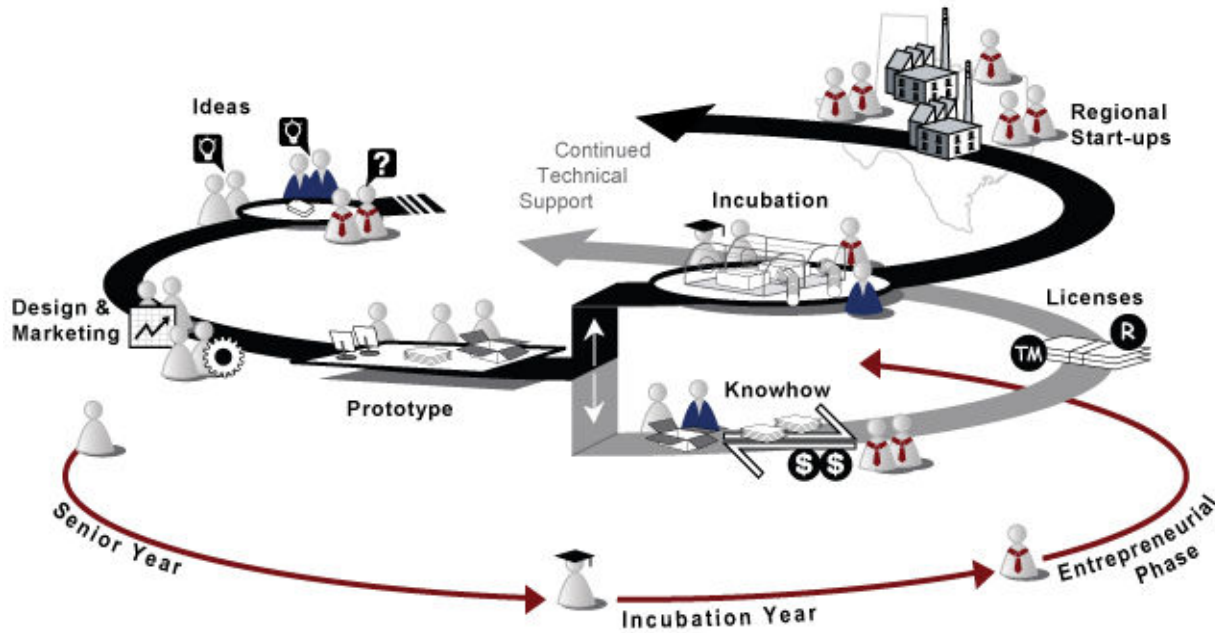
The E4 Model

The E4 Initiative is based on a formal model that augments and extends the senior capstone design sequence with entrepreneurial activities. The following section discusses this conceptual model as is currently being implemented by the Programs. As shown in Figure 2, the E4 model begins with the idea/concept process. At brainstorming sessions with private industry, faculty and undergraduate students starting their capstone experience, new ideas for products and systems will be identified for development. It is generally agreed in these brainstorming meetings, that ideas offered up will be owned the students and Texas A&M University. This avoids any confusion about IP ownership later on in the process.

To resolve any issues with undergraduate intellectual property rights, before brainstorming starts, students participating as inventors will be briefed on University intellectual property (IP) rules and will be asked to voluntarily sign an IP agreement. This practice is already in place. Through the two-semester planning-implementation course sequence, student teams will transform the idea into a fully functional prototype that can be used for test and evaluation, marketing, and documentation purposes. Currently, the two-semester sequence focuses on the technical side of product development. To augment the student’s education, each E4 student team will also have one student member from the Mays Business School who will also have the opportunity to participate as an inventor. The engineering students are in charge of the technical aspects of the product development, and the business students will prepare preliminary business plans, perform marketing assessments, and create marketing materials for the new company. At the end of the second semester, the E4 student teams will deliver a combined technical/business/marketing presentation to invited private sector and business development representatives. Based on potential for commercialization and student commitment, each project can follow one of two paths: the new venture path (regional start-ups) or the technology transfer path (licenses). The decision of which path to follow is made by the students and faculty based on maximizing the ultimate success of the product and the student team.

New venture path. Some products/systems will take the incubation/startup path. If selected, the students who have now graduated will be offered the opportunity to continue in the development of a new business through a technology incubator located on campus and dedicated to the undergraduate experience. The incubator will provide resources to operate a maximum of four start-up companies simultaneously. Each company will receive one full year of support to

develop and grow its business. Support will consist of legal, business, marketing, sales, and insurance advice and counseling, as well as free rent and utilities in the incubator.



COMMUNITY SUPPORT	Brazos Valley Small Business Development Center, Research Valley Partnership, City of College Station, City of Bryan	
AGENCIES	Office of Technology Commercialization, Texas Engineering Extension Service, Texas Transportation Institute	
INSTITUTIONS	Texas A&M University, Prairie View A&M University, Texas State University	
INDUSTRIES	Banyan Tree Holdings Group	
 Students (Undergraduate, Graduated)	 Faculty	 Private Sector, Entrepreneur

Figure 2. E4 Model.

Following this year of support, the company should be ready to transition from the incubator. Local economic development councils have already committed to working with these start-up businesses when they move out of the incubator and offer incentives to keep them in the Brazos Valley. It is the intent of E4 to have two businesses transition out of the incubator and be replaced with two new start-up ventures each semester. These start-up ventures provide a focus of interdisciplinary activities through the partnership formed between academia and the private sector. A reasonable ownership in the new companies will be realized both by the University and the private sector partner(s) involved commiserate with resources provided. Through a formal agreement process, team members choosing not to be directly involved in the incubator process, will have the opportunity to participate in the ownership of the new venture through direct financial contribution or in-kind commitment.

Technology transfer path. Other products will follow the technology transfer path. The University will work as the agent for the inventors (students and faculty), and negotiate with interested companies to license and transition the product know-how to the private sector for

production and commercialization. Each semester new student teams build on the technical knowledge and capabilities of the previous E4 teams.

E4 Progress

Substantial progress has already been made towards implementing the E4 Initiative. As previously indicated, a successful process is currently in place that takes student teams from an idea to a commercially-viable prototype. All student team must formulate an idea and analyze it through an informal market study that is presented to and approved by a faculty/industry team. The teams then have nine months to develop a solution and implement a professionally-packaged, fully-functional prototype. Details on this nine-month, two course sequence have been discussed previously.¹⁻³ To help supply students with physical resources, the Mobile Integrated Solutions Laboratory was created about four years ago. MISL is a physical laboratory space that houses laptop computers available for checkout, electronics test equipment, hardware and software development kits, and PCB manufacturing equipment. The lab now supports several capstone design teams each semester.

About one year ago, it was realized that while the programs did an excellent job preparing students technically, they were not receiving either adequate business/marketing/entrepreneurial education or support. This is now being address through several mechanisms. First, a seminar series has been created to expose students to the real-life experiences of regional entrepreneurs.³⁰ The Ethics, Leadership, and Entrepreneurship Seminar is mandatory for all senior students in their first semester of the capstone design sequence. Student teams are tasked with identifying and inviting a regional entrepreneur to deliver a seminar session, working with the guest to develop a topic/focus for their session, coordinating the actual seminar, and then taking their guest to dinner to develop a longer term relationship. The seminar is done in a round-table fashion with the hosting student team sitting at the table with the speaker. Once the topic is presented, all students in the seminar are given an opportunity to probe the speaker's experience and knowledge. The seminar has now been run for one year and has been extremely successful. Guests have included officers in regional startup companies, senior personnel in large companies, and former University President Robert Gates.

Second, the faculty in the EET/TET Programs approached the Mays Business School about nine months ago to develop a joint curriculum where three to four engineering technology students and one to two business students would partner to form capstone teams. In this manner, the team could, in parallel, explore both the technical and business aspects of creating a product and forming a new startup venture. Faculty members from the marketing and management departments were extremely receptive to this idea, and a formal arrangement is currently being pursued. In the interim, one trial team has been created where MBA students have partnered with undergraduate ET students. These students have developed a product targeted at firefighter safety and have written a preliminary business plan. In addition to actual product development, the team is representing the University in regional, national, and international business plan competitions. In addition to forming interdisciplinary teams, the EET/TET Programs and the Mays Business School are in the process of identifying key business courses that ET students can take as their technical elective. The ET students will also voluntarily take the "Business 101" weekend workshops offered by the Center for New Ventures and Entrepreneurship.

Third, the Programs have been working with the University's Office of Technology Commercialization (OTC) to develop strategies for dealing with undergraduate and joint faculty/undergraduate intellectual property (IP). The OTC has now created formal agreements that allow the University to represent undergraduates in business and IP negotiations. The OTC has also agreed to provide students with education on intellectual property protection.

Fourth, the local community has opportunities to support local business ventures including economic incentive packages and small business education classes. The EET/TET faculty has approached the cities of Bryan and College Station as well as the regional Small Business Development Center (SBDC) and has received support for the E4 Initiative. This support has come in the form of letters of support for proposals, free small business educational support for participating students, and agreements by the cities to formally review student teams for startup potential and local economic incentives. The SBDC has also agreed to allow interested students to participate in their ongoing small business workshops.

Finally, to succeed the E4 Initiative needs an initial investment of resources/capital. The faculty has currently submitted two proposals to secure the resources needed for this concept. An NCIIA proposal was recently submitted to support the initial formation and operations of joint engineering technology/business student teams. Also, an NSF Partnerships for Innovation proposal was submitted to seed an incubator that would be available to students interested in further pursuing their business after graduation.

Examples of Success

To date, the E4 Initiative has had several success stories to report. First, many teams have taken their idea to a truly commercially-viable prototype. This is evidenced by the external interest these prototypes have generated. As discussed previously, the team that produced the Autotune product has received industry interest in their product and is in ongoing negotiations with venture capitalists to continue the development of their idea. In addition, industry has approached the University about licensing technology developed as part of E4. A product called CellLink which enables the use of an individual's cell phone service as their home phone line received an offer from industry for the know-how to produce the product. At the time, the University's technology licensing office did not have a formal process for working with IP generated by undergraduates and could not respond quickly enough to the offer. However, as part of this offer, the University did generate a formal IP agreement that could be used in the E4 process. This agreement allows the University to represent undergraduate students in IP negotiations. It also allows all parties involved in the development of IP (students, faculty, etc.) to participate in revenue sharing as qualified inventors.

Other examples of success involve student teams competing in business competitions. In 2006, an E4 team competed in Texas A&M University's CNVE IDEAS Challenge. The competition involved presenting a product idea and a plan for commercial viability to a panel of potential investors and industry experts. The team won first place in a field of 400 competitors. Most recently, the current interdisciplinary engineering technology/MBA team discussed previously has been selected to represent the university at regional, national and international business

competitions for the 2006/2007 academic year. Most recently, the team won third place at the Idea to Product UT Austin International Competition for the presentation of their firefighter safety product. The product has generated sufficient interest that the University is helping the team pursue a patent.

Future Work

The Electronics and Telecommunications Programs at Texas A&M University are currently pursuing the full realization of the Engineering Entrepreneurship Educational Initiative. Once implemented, this initiative will bring a real-world, integrated entrepreneurial experience to undergraduate education that includes: exposure to real-world entrepreneurs; multi-disciplinary education that includes both the business and technical aspects of entrepreneurship; introduction to small-business operating principles; and the opportunity to take a product from idea to startup venture. While substantial progress has already been made towards E4, several elements are still being put into operation including:

- Undergraduate Incubator – The Dean of the College of Engineering has dedicated space for an undergraduate startup incubator. The faculty is currently waiting on funding sources to complete the incubator concept.
- Funding Through Endowments – In addition to seeking NCIIA and NSF funding to support E4, the Engineering Technology and Industrial Distribution Department Head has committed to seeking external funding sources through endowments to support E4.
- Formalizing ET/Businesses Teams – It is anticipated that by the Fall of 2007, a formal process for the creation of ET/Business student teams will be in place where all students can receive course credit for participation.

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