

Building an Entrepreneurial Engineering Ecosystem for Future Generations: The Kern Entrepreneurship Education Network

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Abstract

The integration of entrepreneurship and innovation into undergraduate engineering education has been found to enhance student performance and improve retention rates (Ohland, 2004). It also prepares graduating engineers to work in rapidly changing environments defined by a competitive global marketplace. Industry is asking for engineers with better communication and teamwork skills, and most importantly, a broader understanding of how to solve real world problems and create value in the marketplace. While some engineering schools are beginning to integrate entrepreneurship and business concepts into the curriculum, many ABET-accredited schools are slow to react to the needs of industry and the marketplace.

Recognizing that this problem is threatening the quality of U.S. engineering talent, the Kern Family Foundation established the Kern Entrepreneurship Education Network (KEEN) with the mission to create an action-oriented, entrepreneurial mindset among engineering, science and technical undergraduates. The KEEN initiative, launched in 2005, represents a new and unique entrepreneurial approach to improving undergraduate education in the U.S.

This paper shows how building an entrepreneurial ecosystem within and among engineering schools, as exemplified by KEEN, will provide a strong foundation for graduating engineers entering organizations operating in an innovation-based economy. Ecosystems can be defined as environments with interconnected relationships influenced by a variety of factors. An entrepreneurial ecosystem links people by vision, commitment, passion, and innovation surrounding the achievement of a common goal.

The paper has five objectives: (1) establish the need for an innovative and entrepreneurial talent pool coming out of U.S. engineering schools; (2) identify critical skills and abilities that can be taught to fulfill this need; (3) describe KEEN from its inception, documenting how new and innovative entrepreneurship-based undergraduate engineering education programs evolve and take shape; (4) provide an overview and general assessment of the types of programs KEEN schools are developing and the impact the KEEN initiative is having on advancing undergraduate engineering, science and technical education; and (5) present a new, staged continuum model of entrepreneurship education that will be used to further develop and assess each school's KEEN program impact and sustainability.

The findings include a series of real world examples and ideas of how to develop new and valuable educational programs and activities that better prepare undergraduate students to work in established enterprises, emerging businesses and start-ups.

1 - Introduction and Overview

1.1 - Competing on Innovation

Entrepreneurial thinking and leadership are fundamental factors in the creation of new enterprises and the sustained competitive advantage of both large and small businesses. The ability to foster an entrepreneurial mindset across generations is a major element of business continuity and longevity. This ability is instrumental in effective strategic execution, innovation and growth. Cantillon (1755) recognized the entrepreneur as an individual who accepts an element of uncertainty in the course of profit-seeking business activity. Timmons and Spinelli (2004) define entrepreneurship as creative human action that builds something of value from almost nothing through the pursuit of opportunity beyond the resources one actually controls. Entrepreneurship links vision, commitment, passion and people to a common cause. Table 1 presents four different types of entrepreneurship in the marketplace.

Table 1: Types of Entrepreneurship with Examples

<ul style="list-style-type: none">• Entrepreneurship and New Venture Formation – Creative human act that builds something of value from almost nothing at all: YouTube• Industrial Entrepreneurship – Innovative activities within manufacturing, supply chain, logistics and facilities: Phoenix Closures*• Corporate Entrepreneurship – Champions leading ideas from development to complete profitability: Apple Computer• Social Entrepreneurship – Mission-related work focused on solving social problems, challenging hegemony and alleviating suffering: Charitable Leadership Foundation’s Project Lead The Way Program to help prepare future engineering & technical workforce in America

*See Table 2: Example of How Phoenix Closures Leverages its Ecosystem

Innovation is the essence of entrepreneurship and is now recognized as the single most important ingredient in any modern economy (Kelley, 2005). In his most recent book “Innovation Nation” best-selling author John Kao sets forth a compelling argument that America is losing its innovation edge. Arguing the primary key to national success is human capital, not financial capital, he convincingly documents the decline of U.S. students selecting to study science, math and engineering studies, as demand for people with such skills continues to increase annually. The American Society of Engineering Educators confirms this, reporting that since 2003 undergraduate engineering enrollment is flat, while both graduate and doctoral enrollment has decreased significantly (www.prism-magazine.org, 2005).

Business executives and public sector leaders from around the world are also striving for innovation. IBM conducted a global CEO study “Expanding the Innovation Horizon” based on interviews with 765 executives and leaders (IBM, 2007). They identified four key innovation themes: 1) *innovation agility* (adaptation to the rate and magnitude of change); 2) *business model innovation* (creation and management of a broad mix of innovation models); 3) *external collaboration* (creation of a global ecosystem, centered on relationships among people); and 4) *orchestration from the top* (integration of business and technology).

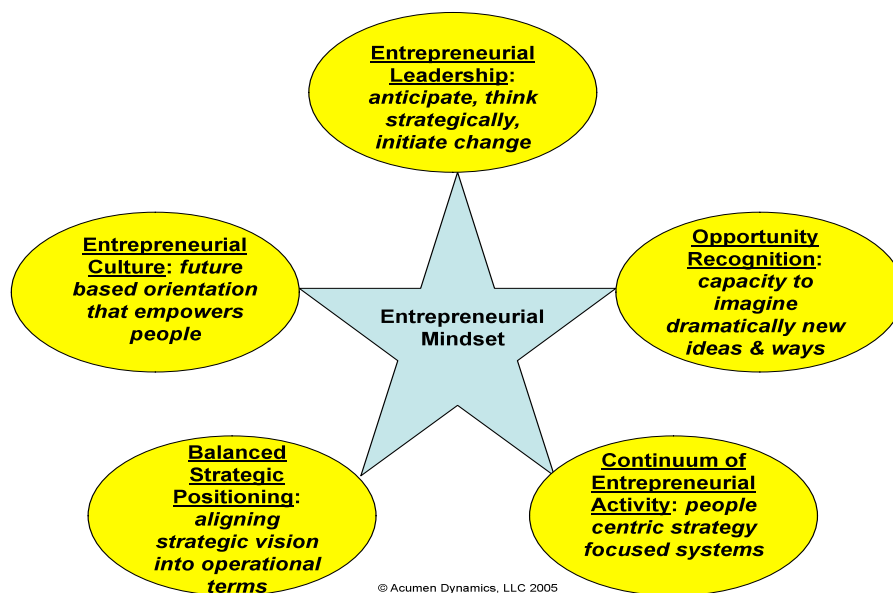
Today, more than ever, our businesses, educational institutions and communities must compete on innovation. The U.S. needs to replenish and strengthen its talent pool of innovative thinkers

and leaders for the future. At the core of this challenge is the need to foster an entrepreneurial mindset in our young people.

1.2 – Fostering an Entrepreneurial Mindset

Companies that compete on innovation are led by people who have an entrepreneurial mindset. An entrepreneurial mindset is built on three primary behaviors: 1) seeking opportunities to solve problems in the company, for its customers, and its community, 2) focusing on creating value for customers and the community, and 3) engaging the marketplace by being in contact with customers, suppliers, universities and the community. An entrepreneurial mindset provides inspiration and identity for a firm and its employees (Figure 1). It creates an entrepreneurial culture, encouraging a continuum of activity that is fundamental to helping firms be innovative.

Figure 1: Key Components of an Entrepreneurial Mindset



Those employing an entrepreneurial mindset constantly scan the horizon for opportunities. This way of thinking can be spread through an enterprise by encouraging employees to focus on opportunities to solve problems rather than on resources or structure. As entrepreneurs and their employees identify timely and favorable opportunities with potential for success, they work together to solve problems and create value for customers.

The principles and concepts associated with an entrepreneurial mindset are core to the socioeconomic fabric of the U.S. To sustain our competitiveness as a global innovation leader, we need to maintain and strengthen a vibrant innovation ecosystem rooted in practicing the behaviors related to the entrepreneurial mindset.

1.3 – Fostering and Maintaining an Innovation Ecosystem based on Value Competing on innovation requires a company to drive entrepreneurial thinking within all levels of the organization and connect it throughout its ecosystem. The vision of the entrepreneur must be translated into the strategic logic of the organization. Value innovation is the simultaneous pursuit of providing superior value to customers and lower costs to the company. Instilling value innovation across the ecosystem helps unify a company by creating a network of champions and

relationships. Organizations that operate through an innovation ecosystem are engaged with the marketplace, including customers, suppliers, the government and professional service providers; and are therefore competitive. The ecosystems within which companies operate are complex and include both internal components as well as external aspects of the community. An ecosystem based on value innovation is systematic and holistic; it is considerate of all aspects of the community. For businesses, innovation is about new value, not just new products.

Phoenix Closures, from Downers Grove, Illinois is an excellent example of an innovation ecosystem that has been successful through fostering an entrepreneurial mindset throughout the company. This mindset has instilled a strategic approach focused on solving customer problems and has helped the company engage customers. For example, one of Phoenix Closures' major beverage customers was suffering significant decline in the sales of its lead product. By rallying around the common objective of increasing sales of their customer's product, internal subgroups at Phoenix Closures worked with their customer to design, prototype and produce a revolutionary and cost-effective new bottle cap that helped turn sales around. Table Two provides an overview of how Phoenix Closures influences and interacts with its ecosystem to compete on innovation, in other words how it leverages its ecosystem.

Table 2: Example of How Phoenix Closures Leverages its Ecosystem

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|--|
| <ul style="list-style-type: none">• Established family business continuity and generational succession, grounded in good communication protocols between family and business.• Integrated and utilized outside expertise including professional service providers, universities and suppliers.• Evaluated and measured vendor/supplier performance and made appropriate changes.• Encouraged a problem solving mindset based on strong customer focus and spending time in the marketplace. |
|--|

Source: KEEN Industrial Lecture Series, IIT, Fall 2006-07 <http://www.iit.edu/~entrepreneur/#keen>

This example illustrates how a manufacturing firm uses its ecosystem to leverage a growth and learning orientation. This orientation helps Phoenix Closures determine where, when and how to compete. Phoenix Closures has created a type of innovation radar that interacts with different parts of the internal and external ecosystem. They use this to accumulate knowledge on how to provide solutions to their customers' problems. By visualizing and prototyping products in a team environment with customers, suppliers and their "customers' customers," Phoenix Closures has managed to produce 15 patents in three years.

New graduates entering these innovative companies, and other organizations that have not yet established an entrepreneurial mindset, need to learn how to add value and create or replenish the innovative ecosystem.

1.4 – Promoting Critical Skills, Capabilities and Experiences

Educators need to take note of the skills needed in industry and integrate them into the curriculum to build a successful pool of innovation talent. These factors are critical to students' early careers both on campus and as entrepreneurs, engineers, scientists and educators. According to a group of entrepreneurs and industry leaders from across the State of Illinois,

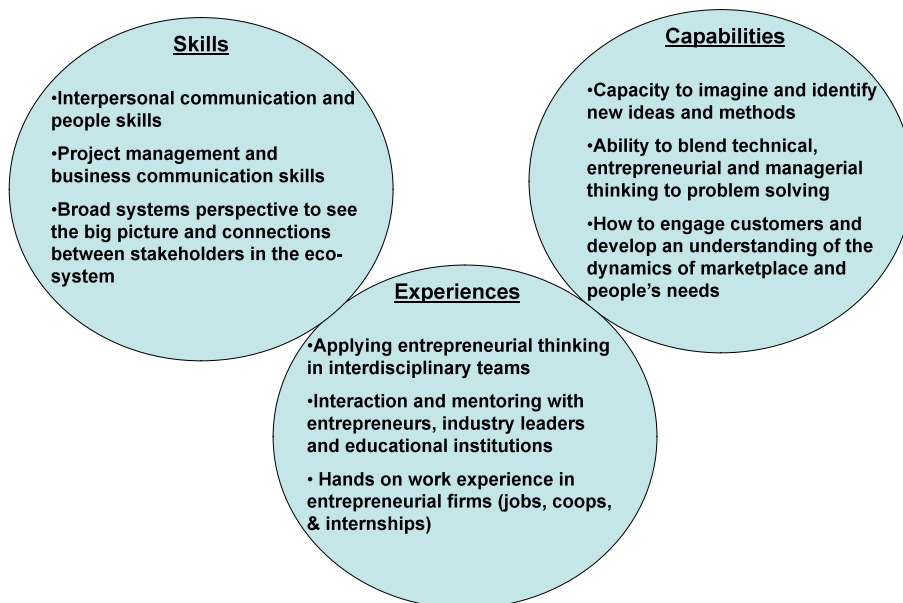
students need skills and capabilities that transcend the technical, scientific and business aspects of entrepreneurship, innovation and business development. They fall into five categories

1. Creative thinking and problem solving
2. Broad systems perspective that looks at subsystems of an ecosystem and culture
3. Technical knowledge channeled toward value creation
4. Interpersonal and human skills
5. Communication skills including written, verbal, and sales techniques

Figure 2 presents a synopsis of the conclusions generated through a series of 25 in-depth ethnographic case studies conducted under the “Innovate Now: Report on Innovation” project supported by the State of Illinois (www.innovatenow.us). The research was conducted during 2007 through a collaborative effort which included Illinois Institute of Technology, University of Chicago, Northwestern University, University of Illinois Urbana – Champaign and Southern Illinois University.

The critical skills and capabilities students need to possess to help industry compete on innovation, and the kinds of experiences that will help them obtain these skills are outlined in the figure below.

Figure 2: Critical Skills, Capabilities and Experiences that Students Need



1.5 – Closing the Gap between Theory and Practice

To close the gap between theory and practice, universities (especially engineering, science and technology departments) need to adopt the following strategies to support the development of entrepreneurship:

1. Make entrepreneurship and innovation education a priority on every campus.

2. Develop and support a group of “innovation champions.”
3. Demand cross-curriculum and interdisciplinary collaboration between students, faculty, universities and the community.
4. Invest in educating and building the knowledge and skills of educators and community leaders.
5. Connect the regional university communities with entrepreneurs, industry, and government to enhance strategic competitiveness.
6. Build a regional coalition of universities, community colleges, and high schools around entrepreneurship and innovation.
7. Raise the funding necessary to support such initiatives and develop a leadership council to direct and lead such efforts.

These high level strategies can be accomplished by weaving them into four core components:

- 1) *Curriculum-centered activities*, focused on embedding entrepreneurship and innovation courses across the university, especially within engineering, the sciences and architecture;
- 2) *Student-centered activities*, focused on student interaction with entrepreneurs, scientists, industry and community;
- 3) *Faculty-centered activities*, designed to unite faculty around the concepts of innovation, entrepreneurship and link regional schools; and
- 4) *Community-centered activities*, focused on uniting and connecting our campus with entrepreneurs, scientists, faculty, students and other schools.

These four components, student-, faculty-, curriculum-, and community-centered activities are the focus of an entrepreneurship initiative on several U.S. campuses as part of the Kern Entrepreneurship Education Network. They are described more thoroughly in section three.

2 – Origins and History of the Kern Entrepreneurship Education Network

2.1 – Entrepreneurship in Action: Robert and Patricia Kern

The Kern Entrepreneurship Education Network (KEEN) is one of many programs supported by the Kern Family Foundation to increase the quantity and quality of engineering talent in the U.S. Though the initiative was created in 2005, the story of its origins and that of the Foundation date back to the 1950s, when as a young mechanical engineer Robert Kern started a generator manufacturing business in a garage in Wales, Wisconsin with his wife, Patricia, and one assistant.

Despite many setbacks, this business eventually grew to become Generac Power Systems, one of the world's largest independent manufacturers of complete engine-driven generator systems. The

company makes power generators for several applications, including industrial, commercial, residential, recreational, vehicle and communications, with systems that range from three to 6,000 kilowatts.

Throughout his leadership at Generac, Mr. Kern upheld a culture of constant innovation, which led to the company's success, and its survival during challenging times. For example, in the 1970s Generac was primarily making portable consumer generators. Mr. Kern recognized the threats of a recession, an oil embargo and the increasing production of Japanese-made engines to his business. He knew that in order to survive in the environment, Generac needed to shift its attention to a new customer base. Therefore, Generac then began producing industrial-scale generators.

Mr. Kern also encountered challenges in finding native talent and had to go abroad to find such innovation. This lack of American human capital in science, math, and engineering gave him cause for concern.

Increasing talent and opportunity abroad threaten the United States' economic leadership. In the words of Curtis R. Carlson, President and CEO of SRI International, we have two options "innovation or death". Innovation is "the basis for increased productivity, competitiveness, and national wealth" and yet it is not integrated into educational system (Carlson and Wilmot, 2006).

Consequently, the Kerns see the need in our country for reforms in science education at the secondary and post-secondary level. Their hope lies in the next generation. Through their foundation, they take action to create value in the lives of those who can effect positive change now and in the future.

2.2 – Seeing the Need and Taking Action: The Kern Family Foundation

The Kern Family Foundation funds two broad impact, long-term programs to address our country's need for a technically competent citizenry and a globally competitive economy based on innovation.

At the secondary level, the Foundation partners with Project Lead the Way (PLTW), a nationally acclaimed middle and high school pre-engineering program created to prepare our future workforce for high tech, high wage jobs. Its mission is to create dynamic partnerships with schools to prepare an increasing and more diverse group of students to be successful in science, engineering, and engineering technology.

PLTW provides a high rigor, project-based curriculum meeting national science and math standards, professional development for teachers and guidance counselors and a comprehensive national support network. PLTW courses are accessible to college-bound engineering students as well as students who may not have thought of college and a career in a technical field. The courses aim to instill problem-solving, teamwork, communication and leadership skills in students. Nationally, there are more than 2500 registered schools in 49 states, reaching well over 200,000 students (www.pltw.org).

At the collegiate level, the Foundation created the Kern Entrepreneurship Education Network initiative. It responds to the finding that, though many engineering schools are beginning to

integrate entrepreneurship and business concepts into the curriculum, the vast majority of ABET-accredited schools are slow to react to the needs of industry and the marketplace. The KEEN initiative represents a new and unique entrepreneurial approach to improving undergraduate education in the U.S.

2.3 – Mission of the Kern Entrepreneurship Education Network (KEEN)

KEEN's mission is to create an action-oriented, entrepreneurial mindset among engineering, science and technical undergraduates. It aims to instill values characteristic of the entrepreneur, including vision, passion, creativity, innovation, optimism, opportunity recognition and persistence.

Mr. Kern explains his commitment to KEEN, noting “our vision is not just to teach students how to start their own businesses, but to prepare them to think *entrepreneurially*, particularly more broadly and deeply about how their ideas fit into their environments.”

He continues, “To do that students need an understanding of finance, business and interpersonal relationships. They need to develop communication skills, specifically how to present ideas; and they need to learn how to listen to the needs of others.”

KEEN is built on the conviction that engineering students will make greater contributions to business success if their engineering education includes an effectively integrated entrepreneurship education program. It aims to fulfill this mission by supporting the creation of programs that develop technical leaders with strong skills and an entrepreneurial mindset in undergraduate engineering programs at select private U.S. colleges and universities. KEEN schools cooperatively identify best practices in entrepreneurship education at the undergraduate level and share these practices among institutions.

The long-term goal is for these new KEEN engineers to catalyze a transformation in the workforce and to build economic and technical commerce in their communities.

2.4 – Launching the Kern Entrepreneurship Education Network

Twenty-four universities were invited to the KEEN inaugural meeting on October 7, 2005 in Indianapolis, Indiana. Eligible institutions consisted of private Midwestern universities with ABET-approved undergraduate engineering programs. Twenty of the original universities received \$5,000 planning grants to develop proposals to implement curricular and extra-curricular components to augment their undergraduate engineering programs in support of the KEEN mission. Twelve universities submitted KEEN Phase I proposals to the Kern Family Foundation and eleven were funded with \$50,000 to develop their engineering entrepreneurship programs. Each grant recipient named two Kern Fellows, with one of the fellows designated as the Principle Investigator (PI) responsible for administering the grant.

Of the eleven KEEN Phase I universities, four had already established entrepreneurship education programs, with some having engineering and technology components. Over the course of Phase I, lasting from July 1, 2006 to June 30, 2007, one of the universities withdrew from the program. The remaining ten institutions completed Phase I of the KEEN program, with eight of the universities establishing first-time programs in entrepreneurship, specifically for

engineering. Section three presents an analysis and report of the first-year experiences of the ten engineering universities in their efforts to establish entrepreneurship programs in engineering and technology.

2.5 – Building Champions and Seeding the Ecosystem

The critical factor in developing and implementing the first phase of the KEEN initiatives was the identification of faculty champions on each campus. These key faculty leaders saw the value in instilling an entrepreneurial mindset in their students, dedicated themselves to advocating for the infusion of entrepreneurship within one or more engineering programs, and devoted time and energy to developing the aspects of the program that would reach students, both inside and outside of the classroom. Those leading the initiatives reported that, in order to establish entrepreneurship programs on their campuses, they spent more time than they had initially anticipated on building relationships to: 1) foster collaboration across disciplines; 2) gain institutional support; and 3) create and/or strengthen partnerships within the community, some with local business and industry and others through outreach to high school students.

In addition to building relationships among campus and community constituents to implement and expand their programs, initiative leaders also found value in building relationships with other KEEN institutions. Faculty leaders have collaborated with other KEEN institutions by sharing effective entrepreneurship modules and lesson plans, and have also partnered on extra-curricular activities when possible. The goal of this collaboration is to identify best practices in entrepreneurship education at the undergraduate level, to share these practices with other institutions as well as to raise the visibility of the programs and to contribute to the quality of entrepreneurship programs nationwide.

3 – KEEN Phases I & II

The goal of the first phase of the KEEN program was to help universities establish entrepreneurship education programs in engineering and technology¹. While three of the Phase I universities had entrepreneurship programs in their business schools, only one had an engineering and technology component to their entrepreneurship program. This goal was realized by a combination of curricular and extra-curricular activities aimed at exposing as many students as possible to engineering and technology entrepreneurship.

One measure of the impact of Phase I of the KEEN program is to look at the number of students that were involved in at least one of the KEEN activities on their campus. The numbers reported below are grouped in two categories, curricular and extra-curricular activities, which will be analyzed in further detail later in the paper. The most accurate estimate of the total number of students in each category is given in Table 3, after factoring out the possibility of multiple counting (i.e. counting the same student multiple times in the category).

¹ In the case of one school that already had an engineering entrepreneurship program, the goal was to expand the program into new areas of manufacturing technology.

Table 3 - Student Impact

KEEN Phase I	No. of Activities	No. of Students
Curricular Activities	47	1,464
Extra-curricular Activities	136	1,622

What follows is a view, in the aggregate, of where the resources were needed to establish (or enhance) engineering entrepreneurship education programs at KEEN Phase I universities. The first subsection summarizes the curricular components to the programs, the second subsection summarizes the extra-curricular aspects to the programs, and the final two subsections discuss other administrative aspects to support entrepreneurship at the KEEN institutions.

3.1 – Curriculum-Centered Activities: Course Development

The most pressing need of the KEEN schools was to develop content on engineering entrepreneurship for either new or existing courses. Every KEEN institution developed at least one new course on entrepreneurship and added entrepreneurship content to existing courses. In all, eighteen new courses were created, twenty existing courses were modified and nine new outreach courses to high schools or community colleges were created in the first year of the KEEN program across the ten institutions.

One common approach used by the KEEN schools was to introduce entrepreneurship by presenting the new material in capstone design courses². Since many schools created business plan competitions in conjunction with their capstone design shows, it made sense to prepare students with useful material on business plans and elevator pitches just-in-time for their competitions. One of the realizations coming from the capstone design experience in entrepreneurship is that students need to be exposed to entrepreneurship principles earlier in their studies in order to allow them the opportunity to select an appropriate capstone project and learn the principles of entrepreneurship in time for the competition.

Another popular approach used by the KEEN schools to work entrepreneurship into existing courses was to use educational modules to introduce appropriate topics. A module typically covers one aspect of entrepreneurship (such as intellectual property or idea generation) that is presented in one or more class periods. Ideally, a module contains a lesson plan and some type of assessment of student performance in addition to the content on the subject matter. Instructors can choose which modules are appropriate for their courses and what juncture of the course is best for the presentation of the material. All ten KEEN institutions participated in module development during Phase I of the program. Work is underway to package the content of the modules in a manner that can easily be shared with other educational institutions.

Nine of the ten KEEN institutions developed programs to reach into the high schools or community colleges that feed students into the university programs. Each program involved varying degrees of instruction on both engineering and entrepreneurship. These activities ranged from business plan competitions in the high schools to seminars focused on technology

² Capstone design courses are also known as Senior Design courses on some campuses.

entrepreneurship in community colleges. A total of six high school programs, two community college programs and one community outreach program were developed by the KEEN institutions during Phase I of the program. The success of these outreach programs is still being assessed.

3.1.1 - Case Studies

Case studies have been shown to be an effective means of teaching important concepts in a situation-based learning environment. Case studies have also been shown to be useful in teaching engineering concepts (Raju, 2007). It seems appropriate that case studies can be an effective tool to teach engineering entrepreneurship as well. Two KEEN institutions developed a total of seven new case studies in engineering entrepreneurship during Phase I of the program. These institutions are in the process of publishing their case studies to make them available to other educational institutions.

3.1.2 - Entrepreneurship Minors

Two KEEN institutions developed three new entrepreneurship minor programs during Phase I. Two of the new entrepreneurship minors are being offered through the College of Engineering and one is offered through the School of Business. Several other minors in entrepreneurship are under development at the KEEN schools. Three of the KEEN institutions already had entrepreneurship minor programs.

The viability of an undergraduate minor in entrepreneurship is a subject of debate at some KEEN universities. On the positive side, offering a minor in entrepreneurship provides a way of recognizing enterprising students who pursue further education on the topic. On the negative side, there are already a large number of competing minors in the business school for engineering students; will enough students postpone their futures to pursue these options? Still, many other universities have implemented successful entrepreneurship minors; and thus this item continues to be a locally debated issue within the program.

3.2 – Student-Centered Activities: Extra-curricular Development

There are a number of ways that KEEN universities try to involve students and faculty in entrepreneurship outside the classroom. During Phase I, many of the KEEN schools launched entrepreneurship clubs, invited speakers to campus, held workshops on entrepreneurship, sent faculty and students to conferences and established competitions with prize money to reward the top student performers. The following sections describe each of these activities in more detail.

3.2.1 - Entrepreneurship Clubs

Six new entrepreneurship clubs were established at KEEN institutions during Phase I. The new clubs complement the two already existing entrepreneurship clubs at other KEEN schools. One of the new clubs associated with the national organization Students In Free Enterprise (SIFE) while the other four associated themselves with the Collegiate Entrepreneurs Organization (CEO). In many cases, because the club organizes and promotes the entrepreneurship events to the university community, the entrepreneurship club has become the most visible and recognizable presence of entrepreneurship on campus. In the eyes of many at the universities, the entrepreneurship club is, in effect, the franchise-holder of entrepreneurship for the institution. Having an active entrepreneurship organization on campus appears to be a key component to building a successful entrepreneurship program.

3.2.2 - Speaker Series

Seven of the KEEN schools used funds from the grant to bring speakers to campus, with six of the institutions doing so for the first time. In all, there were forty-six speaker events on KEEN campuses that attracted over 1,700 attendees. These events prove to be invaluable to raising the profile not only of entrepreneurship, but of the organization on campus that hosts the event. In many cases, alumni of the university are either asked to be speakers or will attend a speech of a high-profile entrepreneur. Alumni also provide important contacts to entrepreneurs in the community that would be good speakers in future events. Tapping into the alumni network appears to be another key success factor for entrepreneurship education.

3.2.3 - Conferences

Students attended conferences to learn about entrepreneurial topics. Approximately 125 students were sent by four KEEN schools to the 2006 Collegiate Entrepreneurs Organization's national conference held in Chicago, Illinois. Two KEEN schools sent the most students (over 100) with two schools from nearby states sending a total of sixteen students to the CEO conference.

3.2.4 - Competitions

Ten competitions involving students from entrepreneurship programs were conducted at seven of the KEEN institutions during Phase I. Six of the competitions were business plan contests associated with the capstone design courses in engineering. Two were elevator (or idea) pitch competitions in which students had to convey the essence of their entire business plan in a minute or two. Prize money was awarded in all the competitions, with the typical breakdown of awards being: \$2,000 for first place; \$1,000 for second place and \$500 for third place. One unique team competition was created, called the Entrepreneurship Quest, in which student teams had to follow clues and uncover the tasks to complete the eight stages of the competition. An Entrepreneurship Quest is an action-oriented demonstration of entrepreneurial skills in which teams compete in various assigned tasks that are judged by experts. Four of the teams in the Quest were from two KEEN schools.

3.3 Faculty-Centered Activities: Building the Knowledge Base

3.3.1 - Workshops on Campus

One of the pressing needs on KEEN campuses was to educate faculty members on entrepreneurship in a brief amount of time. The most popular approach taken was to host seminars or workshops on entrepreneurial topics. Twenty workshops were held across the ten KEEN institutions, with every university hosting at least one workshop. The type of events varied, from five schools hosting Invention to Venture (I2V) workshops organized by the National Collegiate Inventors and Innovators Alliance (NCIIA) to other schools that organized educational emersions into entrepreneurship called "bootcamps". Attendance at all of the workshop events is estimated at 800.

3.3.2—Conferences

Another common method of bringing faculty members up to speed on entrepreneurial topics was to send them to one of the many conferences on entrepreneurship. Faculty members went on twenty-eight conference trips with nine of the ten KEEN institutions participating.

3.4 – Community-Centered Activities: Institutional Commitments to Entrepreneurship

Beyond the curricular and extra-curricular components to entrepreneurship education, three KEEN institutions also furthered their entrepreneurial programs by establishing new business incubators and centers for entrepreneurship. The details of these efforts are summarized below.

3.4.1 - New Business Incubators

One new business incubator was started as part of the KEEN program at one of the participating institutions in the program. An institutional commitment has been made by the university to find new funding to support the incubator.

3.4.2 - Centers for Entrepreneurship

Two of the KEEN schools used funds from the grant to begin the development of Centers for Entrepreneurship at their university, while a third has used the KEEN grant attention to kick-start activities in a dormant center. In each case, additional funds were needed from the home university to create or reinvigorate the Centers. Each school is in the process of developing a sustainability plan for their respective centers.

3.5 - Expenditures

Ten institutions received grants of up to \$50,000³ under Phase I of the KEEN program, for a total of \$492,540 distributed to the schools. No grant funds could be spent on administration, but the grant also did not require institutional matching funds. The breakdown of how the funds were spent is given in Table 4.

Table 4 - Distribution of Funds by the KEEN Schools⁴

Faculty Salaries	30.8%	\$151,667
Equipment and Supplies	9.2%	\$45,209
Curricular Activities (in addition to salaries)	14.7%	\$72,500
Extra-curricular Activities (in addition to salaries)	15.5%	\$76,460
Conferences and Travel (both students and faculty)	16.8%	\$82,597
Assessment	3.3%	\$16,000
Other	9.6%	\$47,407
Unspent (as of 12/31/2007)		\$700

It is not surprising to find that, given the labor-intensive nature of developing new educational programs, the majority of the funds were spent on faculty salaries. The total additional funds spent by the member institutions on their engineering entrepreneurship programs was \$481,075,

³ Institutions were able to apply for up to \$50,000. Three institutions received less than \$50,000 based on their requests: \$49,700, \$49,895, \$42,855.

⁴ Percentages are calculated only for the dollars spent in Phase I. Since dollar amounts in each of the categories reported by the respective universities has been rounded up, the total exceeds \$500,000.

which almost fully matches the \$492,540 granted by the Kern Family Foundation to the ten schools. This brings the total funding of Phase I of the KEEN program to almost \$1 million.

3.6 - KEEN Phase II

The second phase of the KEEN program aims to help universities develop ways to expand and institutionalize their entrepreneurship programs and reach sustainability. The institutionalization of the program seeks to make entrepreneurship education available to all students in engineering and technology disciplines across the campus. Sustainability is meant to achieve financial viability of the program into the indefinite future. In the spirit of achieving sustainability, each university awarded a Phase II grant received \$50,000 to fund the next *two* years of the program, running from July 1, 2007 to June 30, 2009.⁵

KEEN Phase II was initiated on June 12, 2007 with planning grants of \$5,000 each being awarded to thirteen private universities⁶ with ABET-accredited engineering programs. Five of the thirteen invited universities, and nine of the Phase I institutions, received a \$50,000 Phase II grant; bringing the total number of KEEN schools to fourteen.

The KEEN program continues in its first year of Phase II, with a plan for a third phase of funding to be defined by the Board of Directors of the Kern Family Foundation in the near future.

⁵ Phase I provided \$50,000 for a one-year period from July 1, 2006 to June 30, 2007.

⁶ Ten new schools and three schools which had not received a Phase I grant each received Phase II planning grants.

4 – Developing a New Staged Continuum Model of Entrepreneurship Education

4.1 – Five Stages Model of Entrepreneurship Engineering Education

Table 5 presents a visual depiction of the Five Stages Model of Entrepreneurship Engineering Education. At the heart of the Five Stages model is a commitment to create and sustain the integration of entrepreneurship engineering into the educational philosophy and objectives of an institution. Acceptance and support from top administration is critical. Without this, many programs and initiatives flounder. It is also necessary to identify a faculty champion to lead these efforts.

Table 5: Example of a Team of Champions at KEEN I Program School*

Dimensional Level	Profile	Department/School	Impact
Administrative	President, Provost, Board of Trustees	Executive Offices, Trustee(s) with entrepreneurial industry experience	Becomes one of four core strategic pillars of university, funding to seed and support efforts
Lead Champion	Endowed/Chaired Professor of Entrepreneurship	School of Business, but with University wide mission and strategy	Works across campus to identify other champions
Departmental Faculty Champions	Deans, Department Chairs, Faculty	Mechanical, Materials & Aerospace, Chemical & Environmental, Biomedical, Industrial Technology Management, Business	Approval of courses as technical and professional electives, co-instruction and co-curricular activities, development of new courses
Student	Undergraduate and Graduate students	Cross-campus from engineering, science, business, architecture, psychology and design	Development of active student organization including leadership council, cross campus and KEEN school collaborations
Community	Entrepreneur in Residence, local and global entrepreneurs	Cross-campus engineering, business, industrial technology management	KEEN speakers series (includes web clips), living cases, networking events

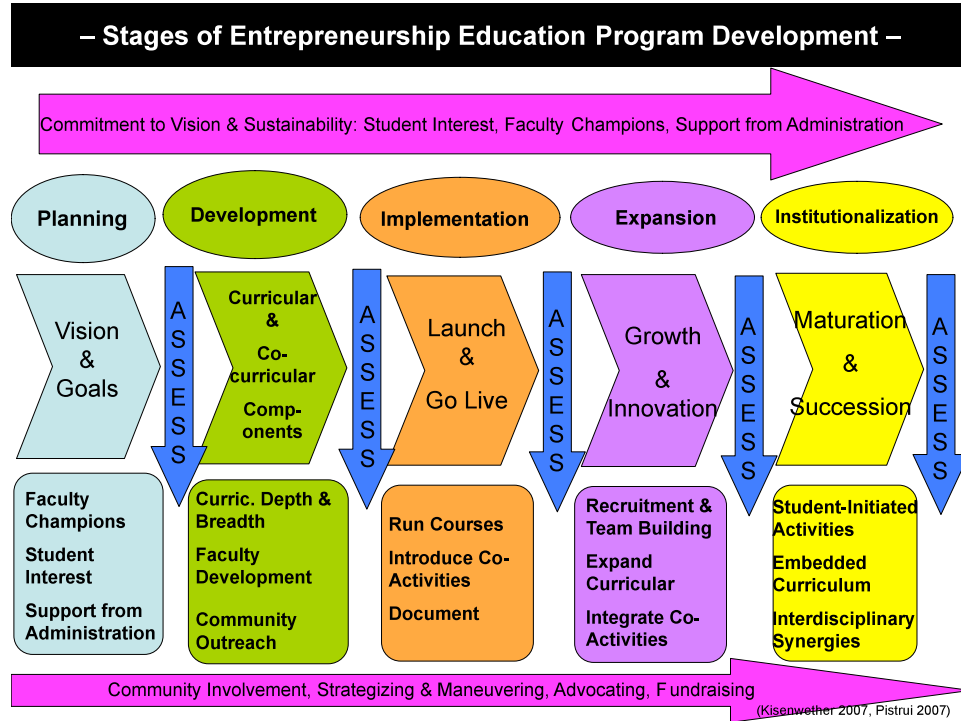
*This is an actual example of a KEEN I Program School's results to date.

Table 5 provides a detailed example of a team of champions at a KEEN I Program School. Often there is more than one champion; most commonly, engineering, science and business faculty unite to initiate change and drive the program. Note that there must be interest at the student level. It is common to find student champions who are motivated to help take charge and lead student participation. The KEEN I programs that have the most rapid impact are the ones that have student, faculty and administrative champions working together to advance the cause.

As Figure 3 illustrates, there are five stages through which entrepreneurship engineering programs move. The first stage is centered on translating vision into goals and objectives which provide a sense of direction and a standard of commitment led by administrative support and a faculty champion. The second stage focuses on development of curricular and co-curricular components. At this stage, faculty development takes place as the initial champion makes an investment into building an understanding of the concepts and components of entrepreneurship. Often this includes reaching out to the community and engaging entrepreneurs and industry leaders who provide real world insights into applied concepts of entrepreneurship.

With a champion, institutional support, and a fundamental body of knowledge, the model moves into implementation stage. In Stage Three, the program launches and goes live. Courses are established and co-curricular activities such as a student clubs, idea generation contests and conference participation occur. These activities lay the foundation for growth and expansion. Stage Four focuses on recruiting new champions and team building. Student teams begin to participate in business plan competitions and faculty attend conferences, presenting papers and workshops related to entrepreneurship education program results and challenges. Co-curricular activities expand into such things as networking dinners, community service projects and student-led initiatives such as fundraising events and partnerships with other universities. During Stage Four, cross-campus integration and collaboration increases. The program aggressively markets, recruits and fundraises across all champion levels. As programs enter Stage Five, the institutionalization stage, attention must be paid to the maturation and leadership succession process. Interdisciplinary synergies and student initiated activities help embed entrepreneurial thinking across the university.

Figure 3: Five Stages Model of Entrepreneurship Engineering Education



It is important to note that across all stages of the entrepreneurship education development model, assessment is taking place. Early on, it is relatively basic (e.g., recording the number of students participating, the number of events taking place, the number of faculty engaged). As the programs develop, more sophisticated methods are employed. Pre- and post- testing of students’ understanding of the concepts associated with entrepreneurship and innovative thinking is an example of such methods.

4.2 – Integrating Curriculum, Co-Curricular, and Community Dimensions

At the core of the Five Stages Model of Entrepreneurship Engineering Education is the integration of the curriculum, co-curricular and community dimensions. Table 6 presents four different integrative approaches to curriculum development. Each approach has its own unique advantages and disadvantages. Selection of approach depends largely on the types of champions in place in combination with the amount of financial support available. KEEN I schools span all four approaches. Some schools are at the planning and development stages, offering classes through a single entity, while some more-advanced KEEN I schools are at the implementation and expansion stages, in which engineering and business programs are working together to advance entrepreneurial thinking university-wide through mixed models.

Table 6: Models of Entrepreneurship Education Curriculum Development

Magnet – Classes in entrepreneurship are offered by a single centralized entity and attended by students from across the university

Radiant – Teaching entrepreneurship is diffused and decentralized throughout the university

Mixed Magnets - Entrepreneurship center or dedicated programs in different schools and colleges across the university

Mixed Model – Part of the entrepreneurship program is university-wide, but the rest of the program stays focused on business and/or engineering

**Streeter, Jaquette and Hovis, 2002*

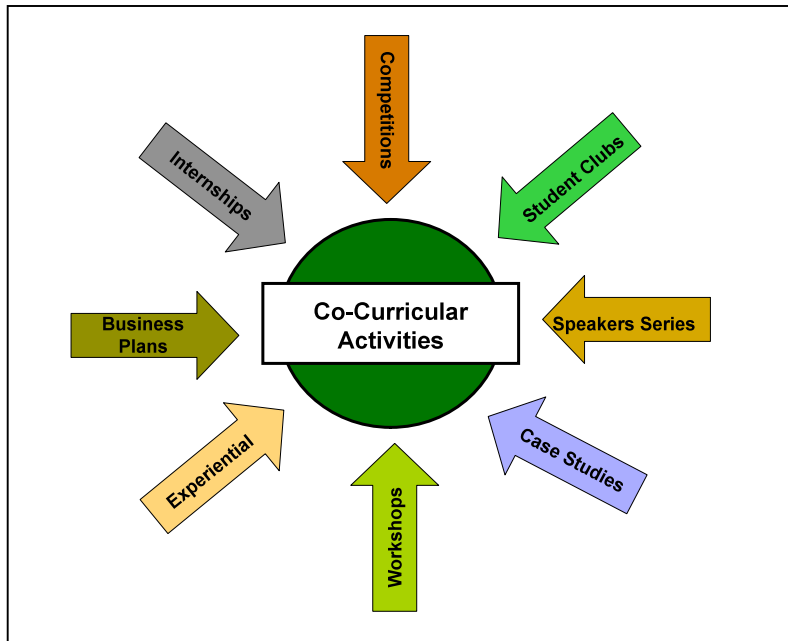
In addition to dedicated courses, several KEEN I schools have also been successful in integrating entrepreneurship components within engineering economics, freshmen introductory courses and senior capstone courses.

Co-curricular activities such as student entrepreneurship clubs, speaker series, case studies and special workshops are also being developed by KEEN I schools. Additional types of co-curricular activities are emerging, including business plan competitions. Some schools have also implemented internship programs which place engineering students in small and medium sized entrepreneurial run enterprises.

KEEN I schools are also engaging in community outreach activities. These activities provide opportunities for students to interact with local entrepreneurs and school districts. One noteworthy example is found in a KEEN I school that has multidisciplinary student teams working on “interprofessional team projects” tied to local manufacturing and industrial companies. In this scenario, students, faculty and local entrepreneurs work together to solve real world problems in the marketplace.

KEEN I schools have made significant progress integrating curriculum, co-curricular and community outreach activities as they strive to foster an entrepreneurial mindset in engineering and science students. Figure 4 provides an overview of the array of co-curricular activities being implemented.

Figure 4: Types of Co-Curricular Activities of KEEN I Schools



4.3 – Strategizing, Advocating, and Fundraising

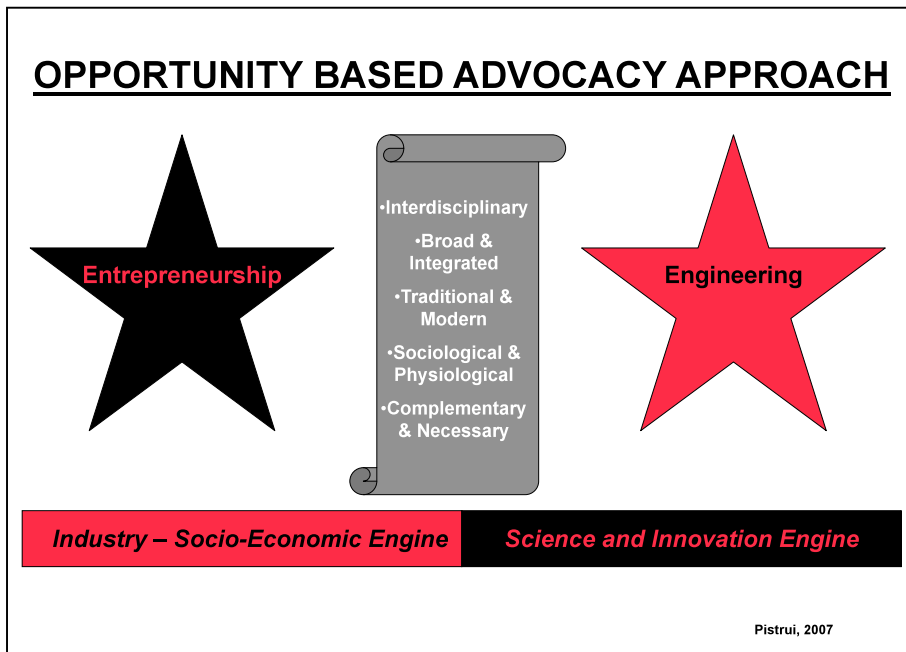
To develop a continuum model of entrepreneurship engineering education, KEEN I Principal Investigators (PI) are actively involved in developing comprehensive strategies to recruit students, gain the support of faculty and administrators, and secure additional funding. Strategic development includes a combination of internal and external activities. One of the greatest opportunities and challenges faced by KEEN I programs is building support within their departments and across campus.

One approach which has proven successful is the “Opportunity Based Advocacy Approach” (see Figure 5). This approach focuses on how engineering and entrepreneurship are interrelated and complementary. In this model, engineering is the science and innovation engine, while entrepreneurship is the socioeconomic engine that drives the outcomes to create value in the marketplace. As Figure 5 illustrates, this approach provides a platform to show the similarities between the disciplines and the ways in which they can be integrated to add value and provide engineering students with a unique combination of academic and practical learning. This approach has particular appeal to students entering the job market. The following example serves to illustrate the impact of such an approach:

An aerospace engineering major with an entrepreneurship minor from a KEEN I school had an internship with NASA during the summer of 2007. Following his summer internship, he applied for a post-graduation full time position. Against competition from hundreds of other applicants, he was offered a position. When he asked why he received the offer, he was told that “the fact that you have a combination of engineering and an entrepreneurship minor distinguishes you from the other candidates and

indicates that you have the interpersonal and business skills critical to the job”.⁷ Examples like this validate the KEEN program and serve as great real world examples that faculty can use to advocate the value of entrepreneurial thinking in engineering and science students.

Figure 5: Opportunity Based Advocacy Approach



The opportunity based approach, along with this type of real world example, provides a solid platform to advocate, build consensus and create a strategy for developing fundraising initiatives. Fundraising needs to be a continual aspect of advocacy. Real world examples of the impact that entrepreneurial skills have in helping engineering students transition from the classroom to industry are a vital part of building a sustainable program.

KEEN I PIs have demonstrated the ability to partner with development and institutional advancement staff to identify additional funding opportunities which will complement KEEN support. Several Phase I schools have been successful in securing matching grants and finding alumni and local entrepreneurs and corporate leaders who will support and advance programs.

4.4 – Assessing, Changing and Adapting

Assessment is one of the most challenging tasks confronting KEEN I schools. Since each of the ten KEEN I schools are at different stages of development, assessment needs to be at both a program and an individual school level. One method of assessment currently being developed is a pre- and post- student survey designed to test entrepreneurial self-efficacy (ESE). ESE is the degree to which a student is confident in his ability to complete successfully the essential tasks of

⁷ Real example from KEEN I student who starts at NASA in June 2008.

an entrepreneur and is strongly correlated with entrepreneurial activity (Chen, Green and Crick 1998). Results to date have primarily been directional and have offered some valuable insights into the impact of each school's efforts. In addition, through a series of KEEN-sponsored workshops, assessment experts have been working with PIs to develop tools and techniques to create new methods of evaluating and measuring the impact of KEEN programs at each school. Finally, standard measures such as number of students participating in curriculum, co-curricular and community outreach activities are being used to assess program impact.

What is certain at this point is that KEEN I schools have gained some valuable insights and practical learning which are being used to modify, adapt and better align their program objectives around the vision, mission, and goals of the Kern Family Foundation's desire to foster an entrepreneurial mindset in undergraduate engineering, science and technology students.

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