

## INSTALLING THE ENTREPRENEURIAL MINDSET INTO ENGINEERING UNDERGRADUATES

**Timothy J. Kriewall\* and Kristen Mekemson**  
**Kern Family Foundation**

**Abstract**—*Engineering is valuable in solving technical problems. Problem solving alone, however, is insufficient to create new-to-the-world products. Engineering leverages the knowledge of technology and is able to bring real value to the global marketplace, especially in the areas of new or disruptive technology capable of improving the lives of others in a global marketplace. New product creation generates both jobs and revenue for companies in which engineers work; it is also the engine that maintains a country’s leadership position in the world’s economy. Engineering education, therefore, must teach engineers-to-be how to be entrepreneurially minded so they can be key influencers in creating new products. This new educational paradigm must include not only instruction in the technical fundamentals of engineering, but also incorporate insight into the importance of customer awareness, an introduction to business principles, as well as a focus on societal needs and values. These precepts need to be integrated into curricular as well as co- and extra-curricular activities.*

*This paper defines the entrepreneurial engineer and explains the means by which KEEN colleges are preparing more entrepreneurial engineers in our society. We describe the structure of the Kern Entrepreneurship Education Network (KEEN), its approach to effecting the changes necessary to train entrepreneurially minded engineers. Champions at network institutions are building strategic relationships within the colleges, increasing organizational capacity (e.g., faculty development,) and growing the base of support at all levels. The network’s intent is to leverage the strengths of the institutions across the network and to build models that can be emulated even outside of the network. This paper also acknowledges challenges in assessing individual impacts, or measurable changes in students’ attitudes, behaviors and skills, outside of anecdotal evidence; we suggests that accumulating longitudinal data will strengthen initial conclusions.*

### 1. Foreword

According to a 2004 report published by the National Academy of Engineering (NAE), “The Engineer of 2020: Vision of Engineering in the New Century,” “If the U.S. is to maintain its economic leadership position and be able to sustain its share of high-technology jobs, it must prepare for a new wave of change...it is agreed that innovation is the key and engineering is essential to this task” (National Academy of Engineering, 2004). The call to adjust engineering education to meet the needs of a global marketplace is undeniable. However, today’s engineering students continue to be trained based predominately on the traditional model of strict technical depth coming out of Cold-War era curricula.

\*Program Director, Kern Family Foundation; W305 S4239 Brookhill Rd; Waukesha, WI 53189;  
[www.kffdn.org](http://www.kffdn.org)

During the Cold-War era, engineering as a field necessarily focused on supporting the establishment, whether military or corporate, through problem solving and development of feature-rich products and processes. However, the post-Cold War era market demands more of today's engineers. When engineering is charged with identifying unmet needs in the marketplace and leveraging disruptive or high-technology-based designs, to fill those unmet needs, then engineering becomes the crux of new market creation, and developing benefit-providing, customer-driven products and processes moves into the fore of the new tools students need to add to their toolboxes.

Engineering, as a field, requires a future-orientation and now incorporates more right-brain creativity and function. Engineers will need to work with and speak the language of their business partners. Each problem will have many potential solutions, none of which has been successfully attempted before; therefore there is a need for *entrepreneurial* engineers.

An entrepreneurial engineer will want to examine problems in the context of the past, yet forge ahead with the mindset of problems as opportunities, in spite of being told "it can't be done." Problems are opportunities for innovation because if solutions were obvious, then the problems would already have been resolved. Further, since many potential solutions may exist, one solution may take a leadership position in the marketplace compared with another solution. Entrepreneurial opportunities require prescient wisdom in order to take customers to where they want to be, though customers themselves may not yet know where they want to go (Hamel and Prahalad, 1994). The NAE's report reinforces this concept, asserting "[e]ngineering will only contribute to [the] success [of our country] if it's able to continue to adapt to new trends and educate the next generation of students so as to arm them with tools needed for the world as it will be, not as it is today" (National Academy of Engineering, 2004).

Although many colleges offer course curricula focusing on innovation and entrepreneurship, these are often limited in scope to business creation and reach a limited portion of the student body. And while traditionally these types of courses have been housed in the business school, recent efforts across the country, through initiatives like the Kauffman Campus Initiative, have spread entrepreneurship education to more students outside of the business school. Still, engineers have a unique perspective on leveraging technology; therefore, a consistent emphasis on entrepreneurial engineering is desperately needed.

The Kern Family Foundation is eager to play a role in helping engineering schools change their pedagogy to develop the entrepreneurial mindset in undergraduate engineers. In order to fulfill this role, the Foundation has created the Kern Entrepreneurship Education Network (KEEN), a network of colleges and universities committed to both this vision and to making the significant cultural changes on network affiliated campuses to accomplish it.

The purpose of this paper is to:

- 1) define the entrepreneurial engineer;
- 2) reinforce the need for more entrepreneurial engineers in our society; and
- 3) describe KEEN's approach to supporting engineering education by creating more entrepreneurial engineers.

In doing so, a long-term systemic change is being pursued to:

- encourage and support colleges and universities to undergo a significant cultural transformation on their individual campuses; and
- facilitate the creation of a network of like-minded institutions.

The concept of the network is especially important because it provides a forum for faculty and administrators to collaborate with each other in order to define best practices in engineering education, especially relating to entrepreneurial engineering.

## **2. Background**

The Kern Entrepreneurship Education Network (KEEN) is supported by the Kern Family Foundation as part of a mission to increase the quality of engineering talent in the U.S., specifically by integrating the entrepreneurial mindset into engineering curricula. Though the initiative began in 2005, the story of its origins, along with that of the Foundation, dates back to the 1950s, when Robert Kern, a young mechanical engineer, along with his wife Patricia and one assistant, started a generator manufacturing business in a garage in Wales, WI. 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 communication, with systems that range from three to 6,000 kilowatts. Over the course of his leadership at Generac, Kern has upheld a culture of constant innovation, which has led to the company's success and survival through challenging times. For example, in the 1970s Generac was primarily making portable consumer generators. Kern recognized the threats to his business: a recession, an oil embargo, and increasing production of Japanese-made engines. He foresaw that Generac's survival in such an environment demanded a shift in its attention to a new customer base, so Generac began producing industrial-scale generators.

Kern encountered challenges in finding native talent when implementing his business strategy; he was forced to recruit abroad in order to find innovative and entrepreneurial engineers. The lack of American human capital in science, math, and engineering gave him cause for concern. Increasing talent and opportunities abroad continue to threaten the United States' economic leadership. In the words of Curtis R. Carlson, President and CEO of SRI International, our country's businesses have two options "innovation or death." Innovation is "the basis for increased productivity, competitiveness, and national wealth," and yet it is not integrated into our educational system (Carlson and Wilmot, 2006), hence the Kern Family Foundation's commitment to educating the next generation.

### ***A. Mission of the Kern Family Foundation***

In keeping with the vision of its founders, Drs. Robert D. and Patricia E. Kern, the Kern Family Foundation seeks to enrich the lives of others by promoting strong pastoral leadership, educational excellence, and nurturing high quality, innovative engineering talent.

The Foundation is committed to supporting strategic causes in the world; the end results of which may not be seen within the course of a single generation. The Foundation programs support and enrich the lives of the next generation of Americans, enabling them to become tomorrow's leaders and innovators.

### ***B. How KEEN Fits into the Foundation's Mission***

In the long-term, the KEEN Program wishes to:

- maintain the quality of life of Americans and preserve the liberties Americans have been blessed with, as a result of the sacrifices and work of those who have come before;

- maintain America's technical prominence in the world; and
- create value in the lives of those who can effect positive change now and in the future.

More specifically, the KEEN program mission is to graduate engineers equipped with an entrepreneurial mindset who will contribute to business success and transform the U.S. workforce.

The program attempts to increase the availability of entrepreneurship education at selected U.S. colleges and universities by supporting the creation of entrepreneurial initiatives within engineering programs. As described later in the paper, network members are beginning to demonstrate some success, which serves as an indicator that other universities may be able to integrate the KEEN theory of change into their own programs.

### **3. Defining Entrepreneurial Engineering**

#### ***A. Entrepreneurial Engineering is not Engineering Entrepreneurship***

It is imperative to distinguish between teaching entrepreneurship and instilling the entrepreneurial mindset into engineering education. In contrast to preparing entrepreneurs, KEEN schools are preparing entrepreneurial engineers.

**Entrepreneurship** is self-employment through business ownership, which has significant elements of risk, control and reward. (This definition of entrepreneurship was coined by John Hughes, the Coleman Foundation's Chairman Emeritus.)

An **entrepreneurially minded engineer** (i.e. an engineer instilled with the entrepreneurial mindset) places product benefits before design features and leverages technology to fill unmet customer needs. The purpose of entrepreneurial engineering is to design value-added products and processes that create demand through innovation, resulting in positive cash flow, revenue, and regenerative profits for the enterprise producing the product.

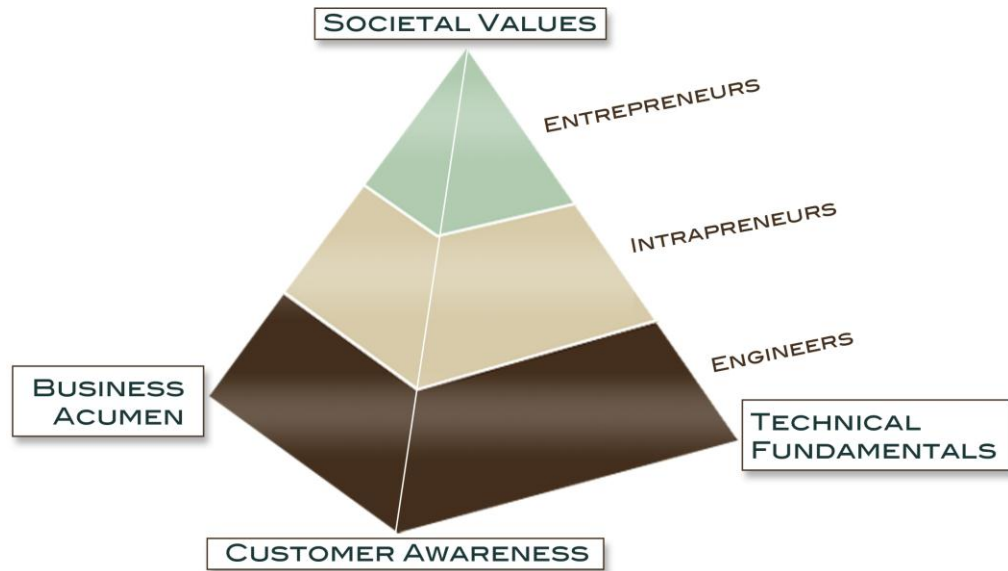
Attributes characteristic of an entrepreneurial engineer include integrity, tenacity, ethics, creativity, intuition, a deep knowledge of engineering fundamentals, the ability to engineer products for commercialization, a penchant for lifelong learning, an ability to see how his or her ideas fit into the larger context of society, and proficiency in communicating his or her ideas.

Entrepreneurially minded engineers are able to fill both the roles of traditional staff engineers, as well as fill the position of intrapreneurial engineers, those who take leadership roles within companies and define, design, create and produce incremental improvements to products intended to retain and/or capture market share in order to stay ahead of competitive products or meet the needs of changing markets. Entrepreneurially minded engineers can also be engineers who are entrepreneurs, those having a personal financial investment in the firms in which they work.

#### ***B. The KEEN Pyramid***

Engineering is the *artistic expression of science and mathematics*. (This definition of engineering was coined by Robert Kern.) Again, anyone equipped with an engineer's toolbox and knowledge of how to use the tools can "fix" a problem. Entrepreneurial engineers will design new products that make life better for others. Thus, engineering pedagogy must sustain engineering education's strict technical depth, while adding the breadth of all that is encompassed in the entrepreneurial mindset.

In terms of the words “entrepreneurial,” “intrapreneurial,” and “engineer,” a pyramidal image (tetrahedron) is proposed which is separated into three horizontal sections (see Fig.1). The bottom section represents engineers—the majority of engineering graduates—while the somewhat smaller middle section represents those graduates who become intrapreneurs, and the smallest, upper-most section represents those who become entrepreneurs.



**Fig. 1:** The KEEN Pyramid depicting the attributes of an entrepreneurial engineer

### **1. The Bottom Section: Engineers**

The base section of the pyramid represents most engineers who graduate from college—those who are, in the traditional sense, “just” engineers. Engineers are intellectual, tool-carrying, technical problem solvers. They excel in problem analysis and design synthesis. Good engineers are able to artistically express mathematics and science through their problem solutions. They are skilled in knowing what to do and how to do it once the problem has been described to them. They tend to have little to no interest in interacting with external-to-the-company, end-use customers. They also tend to be happy working for large or medium-sized companies where long-term security is more likely (compared to small startups). They tend to be motivated by having an intellectually challenging job for which they are adequately compensated; and, by nature, they tend not to be risk takers.

### **2. The Middle Section: Engineers Who Are Intrapreneurs**

The middle section of the pyramid represents a smaller number of engineers who become intrapreneurs—those who desire to be engaged in more of the creative process of new product development. They will be motivated to change the rules of competitive engagement through product redesign. They may also redefine the boundaries of competition by leveraging the core competencies of their employer into new market areas in order to gain market share for their employers. They will have a strong desire to speak directly to end-use customers of the company. Engagement with end-use customers will enable intrapreneurs to learn the unspoken needs of their customers through observation of compensatory behaviors or by observing ways in which technology may be applied to

improve life for their customers. Intrapreneurs will think first in terms of product benefits, not features.

These engineers will be risk-neutral to risk-seeking in their personal philosophy; they will be comfortable with uncertainty. They will be able to make decisions with incomplete information. They will follow Tom Peters' philosophy to *fail forward fast*—that is to say: they will try things to see what works and what doesn't in order to compete for the future (Peters, 1997). They will understand the importance of time to market and will work longer hours and do whatever it takes to get the job done. They will take corporate cash flow into consideration. They will be employees of non-mainstream, somewhat clandestine activities in large companies ("skunk works"), new business development teams of medium-sized companies, or employees of startups where uncertainty will be the highest. They will be members of a team or, with experience, a project leader of a product development team.

### **3. The Top Section: Engineers Who Are Entrepreneurs**

At the top of the pyramid will be a far smaller number of engineering graduates, those who seek to be market innovators. They will be motivated (even more than intrapreneurs) to redefine the rules of competitive engagement, redefine the boundaries of competition or create entirely new markets through the application of disruptive technologies. They will understand the concepts of risk management and competing for the future, and the importance of business development. They will be leaders. Thus, they will need to be able to share their vision of the organization's future, meaning they will have a clear vision, and they will be able to communicate it to their constituencies in terms their constituencies can readily understand.

They will be comfortable with working at the boundaries between the disciplines of their constituencies. Like intrapreneurs, they will do whatever it takes to develop a product that will meet or exceed their customers' requirements. They will have a strong value of service guided by ethical behavior, which will be focused outside the organization, even while being extremely careful to "mind the store" in terms of caring for the organization's financial and programmatic needs.

Engineers in all three of these sections have four defining attributes: working insights into **technical fundamentals**, **customer awareness**, **business acumen**, and **societal needs**.

### **4. The First Corner: Technical Fundamentals**

All engineering programs in America accredited by the American Board of Engineering and Technology (ABET), can demonstrate that they teach the theoretical and technical fundamentals of engineering. However, there is a difference between teaching the theory of engineering and teaching the practice of engineering. KEEN engineering schools will be focusing on both the theory and practice of engineering. In the practice of engineering, the creative side of engineering will be developed (i.e. creativity and innovation) as well as the practical side of engineering, viz.: engineering product concepts for commercialization. Most senior capstone projects focus on first-article, proof-of-concept designs. KEEN programs will teach the elements of design verification, characterization, qualification, validation and standardization for long-term sustainability.

### **5. The Second Corner: Customer Awareness**

Entrepreneurial engineers will first think in terms of product benefits for their internal and external customers before they think in terms of design features. Thus, customer awareness will be the focus of entrepreneurial engineers. They will know how to ask probing questions and, more importantly, how to actively listen.

## **6. The Third Corner: Business Acumen**

Entrepreneurial engineers will have the necessary business acumen to support the organizations in which they work. Business acumen includes understanding the basics of financial management, but it also includes skills in organizational management; viz.: cross-functional team effectiveness, interpersonal communication and conflict resolution.

## **7. The Top Corner: Societal Values**

Societal values sit at the top of the pyramid to show its significance to entrepreneurial engineers' impact on the world. In our increasingly "flat" world, all levels of engineers will need to be aware of how their work is connected to people around the world, particularly as the problems they are working to solve affect more and more people. In this context, those who become engineering intrapreneurs and entrepreneurs will have a keen sense of service to others and will constantly be concerned with how their solutions benefit other people. They will value and help promulgate the free enterprise system. Like all engineers, they will value and promote high standards of engineering and business ethics. They will possess personal character attributes typical of entrepreneurs: intuition, integrity, tenacity, courage, and honesty.

### *C. Finding Their Role*

Although not all engineering graduates will be entrepreneurs or intrapreneurs, all engineers should understand the entrepreneurial mindset. All engineering students will need to know where they desire to fall on the hierarchy of the engineering profession according to the KEEN pyramid. As they are taught the entrepreneurial mindset, those who resonate with the excitement of the unknown will likely seek to learn more about discovery, innovation, creation and risk management. Those who may tremble at the potential downside of entrepreneurial risk management will be happier in less-uncertain career choices than the engineers who become entrepreneurs.

The KEEN program is not set on converting engineers into entrepreneurs, those who wish to start businesses, but rather is committed to the development of the entrepreneurial mindset. Dr. Robert Kern explains:

When we're talking about [engineering] entrepreneurship, the world tends to think that there is some magic here, and that there are one or two little things, and that we just learn these and we have everything under control. This concept cannot be further from the truth. An entrepreneurial mindset is our whole outlook on life, a curiosity level that leads us to understand what is taking place outside of the world we're living in—because ideas can come from anywhere. This curiosity that characterizes the mindset also tells us that life has to become a continuous learning process, and if people are not willing to commit themselves to a continuous learning program, either formal or informal, then they will be left behind. The world's changing too fast and it's a continuous challenge. There's something new to be learned every day. All of this put together wraps itself up to developing an entrepreneurial spirit.<sup>1</sup>

---

<sup>1</sup> Adapted from an interview with Robert Kerns. "Robert Kern States Entrepreneurial Spirit Comes From The Desire To Be Part of A Continuous Learning Process." <http://www.eclips.cornell.edu/entrepreneur.do?id=283>

### *D. The attributes of an entrepreneurial mindset*

In no particular order, the attributes, skills and proficiencies indicative of an entrepreneurial mindset include, but are not limited to their abilities in the following four areas:

#### *Business Acumen*

Entrepreneurial engineers need to be able to tell their new-product story in business terms. They need to be able to negotiate organizational management obstacles by effectively collaborating in a team setting. They need to effectively manage projects and apply the commercialization process. Therefore, the attributes they require are:

- Basic understanding of business and finance (including marketing)
- Understanding of economics
- Understanding of capital
- Good communication skills: listening, speaking, and writing
- Tolerance for ambiguity: making decisions with incomplete information
- Vision
- Passion
- Optimism
- Persistence
- Ability to assess and manage risk
- Leadership (sharing the vision)
- Understanding organizational structure and corporate culture (i.e. business practices)
- Strong interpersonal skills
- Cross-team effectiveness
- Understanding of the role of management (planning, organizing, directing and controlling)
- Understanding the engineer's role within the organization
- Ability to resolve conflict

#### *Understanding Customer Needs*

Entrepreneurial engineers need to be able to recognize opportunities that have a technical solution. They need to construct and effectively communicate a customer-appropriate value proposition. They need to apply critical and creative thinking to solving ambiguous problems. Therefore, entrepreneurial engineers need to have:

- Intuition
- Awareness
- Ability to identify and replace compensatory behavior
- Ability to recognize an unmet need and to act on an opportunity
- Inquisitiveness: asking questions, critical thinking
- Ability to articulate and define a problem
- Innovation: the process of creating and delivering new customer value (Carlson et al. 2006)
- Creativity: ability to think outside the box, changing the rules of engagement, redefining the boundaries of competition, or creating entirely new markets through disruptive technologies
- Altruism
- Empathy
- Prescience

### *Societal Values*

Entrepreneurial engineers need to be able to see the value of their work as it affects society, preserves freedom and liberty and maintains a standard of living which far too many of us simply take for granted. They need to demonstrate voluntary social responsibility. Therefore, entrepreneurial engineers should:

- Value free enterprise
- Supporting personal freedom and liberty
- Serve the needs of others
- Internal customers (i.e. through teamwork)
- External customers (i.e. domestic and international customers)
- Maintain high ethical standards
- Recognize and encouraging the development of future engineers; cultivate the next generation of engineers
- Maintain a global view
- Sustain environmental stewardship
- Have personal integrity, tenacity, courage, honesty and a sound code of personal ethics.

### *Technical Depth*

Entrepreneurial engineers will not only be good by the book in knowing the theory of engineering, but they will be able to practice the art and science of engineering. They will work judiciously to make products designed and tested for commercialization. They persist through failure to do what is needed to succeed. Therefore, the entrepreneurial engineer will know:

- Engineering analysis
- User requirements and performance specifications
- Product innovation
- Hazard analysis
- Design for manufacturing
- Design synthesis
- Design characterization
- Design verification
- Design validation
- Process validation
- Failure analysis
- Product qualification

## **4. Redefining Engineering Education**

The field of engineering must rethink its current methods and systems of teaching the practice of engineering in order to integrate the skills and attributes of an entrepreneurial mindset without sacrificing technical depth. Otherwise engineering will simply become a commodity. The Kern Family Foundation has limited resources, and thus, it has decided to work with a select group of private, independent colleges on this issue.

### A. The KEEN Theory of Change

Is entrepreneurial education taught in a single course? Absolutely not! Do new courses need to be created? Not necessarily. Entrepreneurial engineering can be instilled as part of an engineering institution’s culture. A common misconception of entrepreneurship is that it is motivated by personal wealth generation, sometimes referred to as greed. Perhaps for some generation of personal wealth is the primary motivation for innovation; however really successful entrepreneurs, even those who are in business to make money, are social entrepreneurs: They wish to provide products and services that improve the lives of their customers. As Peters and Waterman (1982) write in their seminal work, *In Search of Excellence*: any company that exists to make money is doomed to fail. Those companies that exist to meet and exceed their customers’ requirements will have profits as a natural consequence.

Companies must make money to exist. Yet making money is not their sole purpose for being any more than any person’s sole reason for being is to breathe oxygen.. Likewise, a business must contribute to society. If every college professor instilled in students a sense of how an engineer contributes to society—through the use of examples in the classroom or through demonstration of societal benefits via business examples—he would be instilling entrepreneurial engineering into the culture of the engineering pedagogy. This could be done in a digital design course, a fluid dynamics class, or a software development class. Alumni could return to campus to give lectures about their own experiences in entrepreneurial engineering, this would amplify the effect. Additionally, if students were given opportunities to develop their engineering practice through co-operative and internship work experiences, entrepreneurial engineering would become a natural part of a school’s culture. In this way, the entrepreneurial mindset would be infused into the existing curriculum and negate the need to add new classes to an already congested course curriculum required for ABET accredited programs.

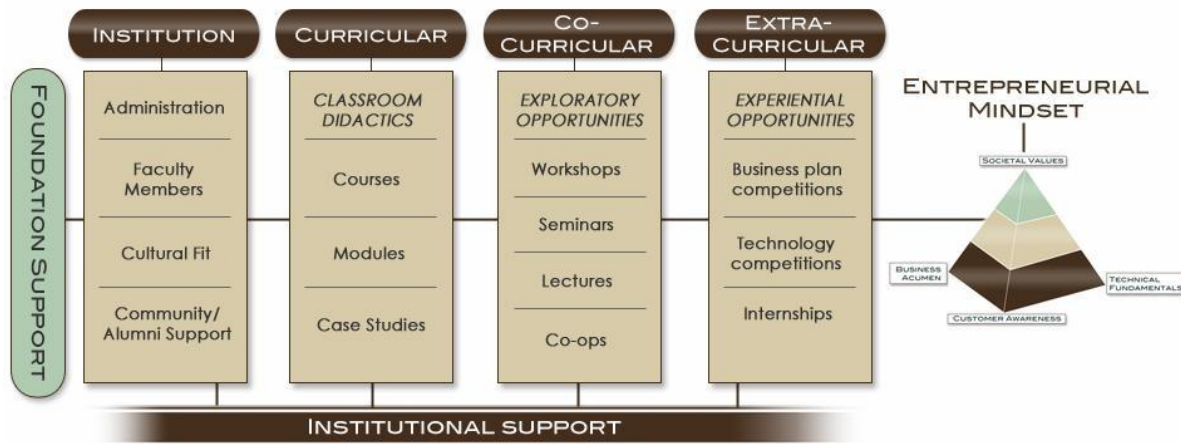


Fig. 2: The KEEN Theory of Change

Figure 2 illustrates the KEEN theory of change: A modicum of financial support functions as a catalyst for change; courses are modified to instill entrepreneurial engineering through examples. Co-curricular educational experiences (those that contribute to college credit) further demonstrate entrepreneurial engineering through case studies. Finally, extra-curricular activities (those not contributing to college credit) provide real-life examples of entrepreneurial engineering. All three types of experience contribute to the KEEN pyramid of entrepreneurial engineering attributes.

The KEEN expectation is that others would see the value of this theory of change and would consequently desire to contribute to implementing this new pedagogy. Their contributions are represented by the horizontal bar at the bottom labeled “Institutional Support.” These are monies and contributions of time and talent that are leveraged as a result of the Kern Family Foundation’s support.

## ***B. KEEN Methods***

At present, twenty educational institutions are involved in KEEN. The institutions are using the KEEN theory of change, as described above, to initiate change on their campuses. While each campus takes a unique approach to implementing this theory, some trends are becoming evident.

### **1. Increase in Organizational Capacity**

Several campuses are working to increase their organization’s ability to teach the entrepreneurial mindset through faculty development workshops. Through these workshops, KEEN-initiative leaders help their colleagues determine how to change the pedagogy in their classrooms. As each KEEN program has developed, increased opportunities for faculty development have trended upward around this particular subject. These activities are one of the most effective practices campuses use to induce culture change.

All current KEEN campuses have embedded either courses or modules within courses (see Table 1) in order to accomplish this. As mentioned before, courses offered in conjunction with other departments such as the business school, or even minors or certificates in entrepreneurship, can be beneficial in reaching students at a certain depth. However, in order to reach a greater number of students, integrating modules on entrepreneurial education can be a much more effective way to increase the reach of the program.

Over and above the grant funding, the Kern Family Foundation puts on an annual fall conference with the express purpose of encouraging faculty involved in KEEN to learn from one another through exchanging ideas and sharing techniques. In this way, the Foundation supports and reinforces each campus’s efforts to increase the capacity of their institutions to adopt and integrate the entrepreneurial mindset into engineering curricula.

### **2. Expand the Base of Support**

KEEN leaders have run into strong resistance from key campus constituents. Thus, parallel to training willing faculty how to teach the entrepreneurial mindset, they also conduct activities to recruit and reach out to new supporters, especially those who have the ability to effect change on campus, whether administrators, influential faculty members, or key staff members. This makes a difference in the number of students who can be reached.

Administrators, too, play a critical role in advancing the KEEN mission. In order to support member campuses in expanding their base of support, the Foundation puts on a separate conference to which KEEN leaders can invite several key players who need more information on the KEEN mission and who have not yet discovered how they can make a difference in this work. The Foundation measures the number of administrators participating in these conferences and has seen an increase in the number attending each year. Furthermore, as evidenced by at least two campuses, when someone within higher administration becomes involved, change tends to be more rapid and widespread. In these instances, provosts have made this effort part of the institutional mission. This has resulted in an

effort on one campus to revise 30 courses to include entrepreneurial engineering content. The other campus is providing a term-long course in entrepreneurial engineering to faculty members who have committed to changing their courses.

A school's base of support also includes students, as they can be great advocates for entrepreneurial engineering. This support is measured by the number of students who participate in activities outside of coursework. Since students are not receiving money or credit, their willing participation indicates that they find these opportunities of value.

### **3. Building Strategic Alliances**

Strategic relationships are another important factor in effecting cultural change on campuses. Entrepreneurial engineering is interdisciplinary in nature. Innovation occurs at the intersection of disciplines. Alliances involve faculty and students across engineering disciplines, faculty and students outside of engineering disciplines, as well as faculty and students at other institutions focused on the same goals. Non-engineering disciplines, like business and humanities, have much to offer to the entrepreneurial mindset. They bring different lenses through which students may see the world along with different experiences that may create opportunities for engineers to understand problems, solutions, business and customers in new ways.

Strategic alliances outside of the university setting involve alumni and local businesses. These constituencies can interface with entrepreneurial engineering education in a number of ways. For example, alumni and local entrepreneurs can come to campus to interact with students through talks or projects, or students may visit entrepreneurial alumni and companies to see their work in action. These true-to-the-world experiences provide relevance and allow students to begin building their own alliances for their post-graduation journey.

The efforts described above—increasing organization capacity, expanding the base of support, and building strategic alliances—primarily involve working with the “gatekeepers” to the target audience: the students. Each of these components is critical to the creation of sustainable programs. If the strategies are only being carried out by one or two champions, and these other pieces are not in place, then the initiative will not reach enough students; and the changes will not be sustainable.

### **4. Making an Individual Impact**

All of these efforts lead to making an impact on the individual engineering student. Differences are observable through the number of students participating in exploratory learning opportunities, experiential learning opportunities, and coursework related to entrepreneurial engineering. These numbers are increasing, but admittedly they represent inputs rather than results. Results are more difficult to measure until sufficient time elapses. For two years, the Kern Family Foundation has administered a self-efficacy survey to students enrolled in KEEN-sponsored coursework. This was useful in measuring the students' levels of confidence in five specific areas associated with entrepreneurial behaviors. However, Foundation staff and KEEN faculty have decided to review and revise their approach to align it more closely with the attributes listed in this paper.

**Table 1: KEEN Data (2008-2009).** The data presented and described above includes information from 22 campuses that were reporting on the 2008-2009 academic year. Two colleges are no longer participating.

<b>Outcome</b>	<b>Measurement</b>	<b>Numbers</b>
Organizational Capacity	No. faculty development opportunities offered by KEEN campuses	15
Organizational Capacity	No. faculty involved in KEEN	170
Organizational Capacity	No. embedded courses re: entrepreneurial engineering	37
Organizational Capacity	No. embedded modules re: entrepreneurial engineering	59
Base of Support	No. conferences attended by administrators of KEEN campuses	79
Base of Support	No. students participating in KEEN-related activities outside of coursework	3,367
Alliances	No. campuses collaborating with business faculty	18
Alliances	No. campuses collaborating with non-engineering and non-business faculty	9
Individual Impact	No. students involved in entrepreneurial engineering related coursework	4,432

## **5. The Power of the Network**

### *A. Core Competencies*

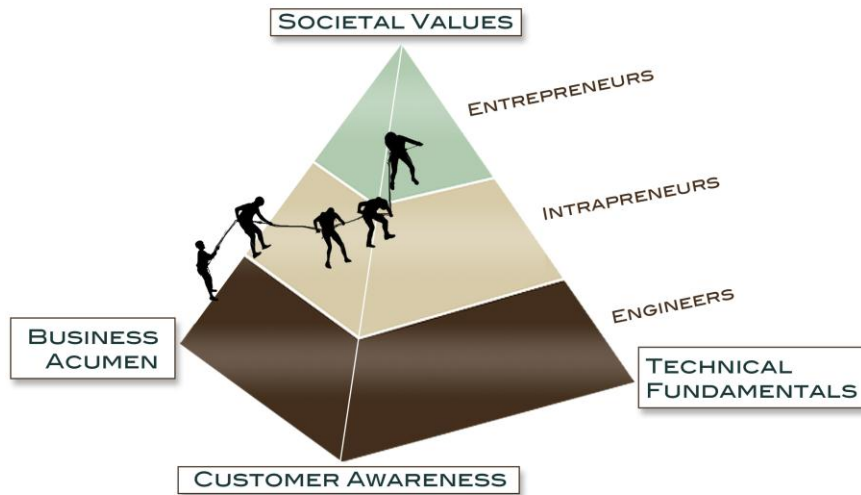
The network of engineering colleges and universities provides a forum for faculty and administrators to collaborate with one another on identification of best practices in engineering education, especially as it relates to entrepreneurial engineering.

Each college has its own set of strengths and weaknesses as well as opportunities and threats just as each institution will have its own set of core competencies. The value of having a network of colleges is that a specific engineering college may benefit from the core competencies of other network colleges. Through cooperation, the strengths of a particular college may be used by others to either avoid duplication of capital expenses or as a model for others to emulate. The true value of the network is not what colleges receive from one another, but rather what they are able to give to one another.

The Network creates a virtual campus with the collective intellectual capital of the combined faculty. The Network also brings together the combined capabilities of its students. This collaboration allows them to learn from each other and synergizes their institutions' strengths to create a team of engineering graduates throughout the United States that will constantly ask "How may I help you live a better life?" By so doing, they will create new markets and new opportunities that will maintain America's competitive leadership position in the world.

## B. Competition or Cooperation?

Competition is generally good. Competition usually instills a desire to work at peak performance. America is in competition with other powers in the world to maintain an economic leadership position. However, competition is not always healthy.



**Fig. 3:** A willingness to cooperate in climbing the KEEN summit characterizes KEEN universities.

Much like members of a group of mountain climbers depend upon one another for each climber's individual abilities, so, too, do the KEEN engineering colleges create a synergistic team, work together to challenge each other and help each other reach new heights in educating entrepreneurially minded engineers. Both the mountain climbers and the network colleges are tied together, so the collective strength of the team keeps anyone who slips from falling. They reach the summit as a team, not as individuals. Any member of the team who isn't willing to hold onto the rope tying all the climbers together endangers both himself as well as his team members. Any member of the team who isn't willing to take the lead, to break new ground, to reach a new highpoint is not a contributing member of the team. Those who don't contribute to the success of the team will find themselves sliding off the KEEN mountain.

## 6. Conclusion

The long-term goal of KEEN is to create a curricular model of entrepreneurial engineering education that may be emulated by others. In the end, a university must be entrepreneurial itself in order to make the transformation, to emphasize entrepreneurial education as fundamental to its pedagogy. The administration, staff, and faculty need to identify unmet needs in engineering education and fill them.

The approach of the Kern Entrepreneurship Education Network is to change engineering education through a process to which all the KEEN colleges subscribe referred to as the KEEN theory of change. The process is tailored to meet the core competencies of each campus. The approach offered

certainly is not the only approach. Currently KEEN engineering colleges agree on the need to change: in this changing world, what is done today is insufficient for tomorrow. Engineering education needs to change in order to create a whole new mindset (Pink, 2005) in engineering graduates.

The change process begins with faculty ownership. Within the KEEN network, faculty participants have validated—through their own professional development experiences and network-based interactions—that change can happen, and they have shown early indicators of expected outcomes, via changed skills and behaviors in their engineering graduates.

The KEEN goal is to ultimately influence 100% of the engineering students on KEEN campuses. Based on the feedback from the Network colleges, over 4,400 students have been exposed to what it means to have an entrepreneurial mindset.

For this change initiative to be sustainable, college administration needs to be directly involved. In fact, evidence indicates that when administration is not involved, and they do not take an active role in supporting the initiative, change tends to not take hold. Two institutions have withdrawn from the Network or have had their support terminated because administration places other priorities, like graduate research, at a much higher priority to undergraduate engineering education. The decision to do so may be correct for those institutions, but that priority does not optimally create work-ready engineers for the commercial business sector.

Furthermore, for sustainability, the college needs to create alliances, increase organizational capacity and strengthen its base of support. Alliances are the strategic relationships the college, its faculty and its administration may create with cross-functional colleagues and universities both within and outside of the Network. Organizational capacity includes the development of sustaining funding, talent and tools needed for long-term growth. The base of support—alumni, corporations, and professional organizations—champions the ongoing effort to recruit and conscript additional people and organizations to help in the creation of the new paradigm. But, as the old adage goes, the proof of the pudding is in the tasting. Assessment of outcomes as measured by changed attitudes, behaviors and skills of engineering graduates remains the true test of this initiative. The results will continue to accumulate over the years. Expectations are that this cohort of entrepreneurially minded engineers will be instrumental in keeping America in its technical leadership position in the world.

## Notes

Carlson, Curtis R. and Wilmot William W. *Innovation: The Five Disciplines for Creating What Customers Want*. New York: Crown Business, 2006.

Hamel, Gary and Prahalad, C. K. *Competing for the Future*. New York: Harvard Business School Press, 1994.

National Academy of Engineering. 2004. “The Engineer of 2020: Visions of Engineering in the New Century.” [http://books.nap.edu/catalog.php?record\\_id=10999](http://books.nap.edu/catalog.php?record_id=10999) (accessed November 4, 2009).

Peters, Thomas J. and Waterman, Robert H. *In Search of Excellence*. Las Vegas, NV: Harper & Row, 1982.

Peters, Thomas J. *The Circle of Innovation: You Can't Shrink Your Way to Greatness*. Vintage Books: New York, 1997.

Treacy, Michael and Fred Wiersema. *The Discipline of Market Leaders*. Toronto: Addison Wesley, 1995.