AC 2010-2218: BRINGING INNOVATION AND THE ENTREPRENEURIAL MINDSET (BACK) INTO ENGINEERING: THE KEEN INNOVATORS PROGRAM

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Abstract

The U.S. economy has gone from being a predominantly innovation-based economy to being a predominantly service-based economy. Historically, this is not a trend that can sustain a nation, and this is especially apparent in the face of the economic downturn in recent years. The challenge is how to bring innovation back into the engineering disciplines, when many of our faculty have never worked in industry, and so are not necessarily aware of the complex and multi-faceted problems faced by industry. The Kern Family Foundation has made it possible, through the Kern Entrepreneurial Education Network (KEEN), to help engineering faculty catch the vision of the need to inculcate innovation into all phases of the engineering coursework, through the KEEN Innovators Program at Baylor University. The charter Innovators have participated in several KEEN meetings and Regional Conferences, finished a sponsored summer of research into best methods of deploying the entrepreneurial mindset into their courses, and helped coordinate the selection and continuation of the 2010 Innovators.

This paper will present the background of the program, the assessment of the first year of the program and its impact on student learning, and future expansion of the program. We will also discuss lessons learned and best practices, including the necessity of working across disciplinary boundaries and the importance of administrative support.

Introduction

Billy Vaughn Koen in his book, "Discussion of the Method," describes the process of engineering as finding the best change within limited resources in an environment of uncertainty. [1] He provides two examples. Both the statements

1. "The chess master engineered the perfect countermove", and
2. "The clergy in Iran engineered the firing of the president",

use the word "engineered" as a verb. In both cases, he argues, the word is used correctly because it describes the determination of the best course of action among many possible ones, constrained by limited resources, in an environment of uncertainty where not all the information required is known at the beginning.

Entrepreneurship, then, could be described as "business engineering" and therefore fits quite naturally within the engineering curricula.

The challenge to reinvigorate the engineering curricula has been recognized by the National Academy of Engineering, the Taskforce on Graduate Engineering, and industry and academia leaders in STEM fields. G.P. Peterson presented a seminar at the 2007 ABET Annual Meeting that outlined the challenges facing engineering and computer science educators.[2] He states that the challenges are enormous because we are preparing students for future jobs that may not

currently exist that use technologies that have not been invented to solve problems that we don't even know exist. Peterson also says that "institutions must design degree programs – with relevant content, condensed time investment, and modified requirements – to meet the changing needs of non-traditional students". He also points out that the employers of our students will expect them not only to be "well prepared in the discipline, but also to possess ingenuity, innovation, creativity, and entrepreneurial capabilities".

This paper describes Baylor University's involvement with a program created by the Kern Family Foundation. This is a private family foundation that was created in 1998 by Robert and Patrician Kern. Mr. Kern's goals in establishing the Kern Family Foundation included the furtherance of his goals in the area of innovation and the reinvigoration of the U.S. economy. The statement of purpose of the foundation states:

> "We are committed to supporting strategic causes in our world, the end results for which we may not see in our lifetime. The programs we support enrich the lives of the next generation of Americans, enabling them to become tomorrow's leaders and innovators."[3]

Baylor University's involvement is with a particular program aimed at engineering entrepreneurship education. This is one of several thrusts of the foundation, all of which deal with innovation in some form. The statement of purpose for this program is:

> "The Foundation created the Kern Entrepreneurship Education Network (KEEN) in 2005 as a collegiate initiative to complement efforts at the K-12 level to increase the quantity and quality of U.S. engineering talent.
>
> KEEN's mission is to graduate engineers equipped with an action-oriented entrepreneurial mindset who will contribute to business success and transform the U.S. workforce.
>
> The long-term goal is for these new engineers to catalyze a transformation in the workforce and to build economic and technical commerce in their communities. This focus on entrepreneurial leaders is increasingly important as the U.S. competes to maintain its economic position in a global marketplace based on innovation."[4]

The KEEN program works only with private universities that have been invited to submit proposals. Their belief is that private universities can make systemic changes more quickly and easily than more bureaucratic public universities.

The KEEN network currently consists of 20 universities. Baylor University is in the third cohort of universities to become involved. In addition to providing financial support for projects, the foundation also supports two conferences each year where the schools get together and learn from each other as well as from practitioners in the field of engineering entrepreneurship education. They are seeking to develop the 20 universities into a true network that can become one of the leaders in engineering entrepreneurship education.

Baylor University was invited to become part of the third cohort of universities in the KEEN

network. In 2007 we received a small planning grant. We used this to further develop both our short- and long-term plans. We received a larger implementation grant in 2008. This paper describes what we are doing as a result of receiving this grant.

Baylor University's KEEN Innovators Program

Baylor University was awarded a $50,000 grant from the Kern Family Foundation in July 2008, and became a member of the Kern Entrepreneurial Education Network (KEEN). The grant was to extend the work done in integrating entrepreneurship with engineering & computer science in three specific ways:

1. Implementation of an intense hands-on, coached learning classroom style to accelerate skill acquisition and demonstration (the SuperCoach® curriculum) in the existing two-course sequence;
2. Creation of a KEEN Innovators program to assist faculty in embedding entrepreneurial content into their engineering and computer science courses; and
3. Formalizing a Technology Entrepreneurship (TE) certificate for engineers and computer scientists and recognizing student receiving the certificate as KEEN Undergraduate TE Fellows.

The purpose of the KEEN Innovators Program Initiative is to encourage the integration of entrepreneurship concepts and skills into the engineering and computer science curricula by awarding a stipend to an Engineering & Computer Science (ECS) faculty member who develops an innovative plan for fostering the entrepreneurial mindset within the course(s) they teach. In addition to the stipend, the assistance of the KEEN grant team will be offered to enable use of best practices developed by others in the network who are building entrepreneurial skills and insights into engineering and computer science courses. This is intended to be a team effort to the extent that assistance is needed. Two awards were made in 2009 and 2010.

The opportunity to apply for this $5,000 summer stipend is available to ECS faculty members only. Proposals must focus initially on those ECS courses that are required in one of the ABET-accredited degree plans.

Applicants are required to write a 1- to 2-page narrative that provides the following information:

1. Description of the courses they are currently teaching, as well as their ideas for how to integrate entrepreneurship within the course or courses they plan to target.
2. Identify the learning enhancements that they will aim to accomplish through this effort, and the numbers of students who will benefit.
3. Description of the assessment tools and methodology to be used to measure the effectiveness of their proposal.
4. A list of any particular challenges or gaps in know-how in which they would like the Baylor KEEN grant team and KEEN members to assist.

2009 KEEN Innovators

As a result of our Request for Proposals (RFPs) for 2009 KEEN Innovators, two ECS faculty

members were selected, based on their program proposals. Their initial proposals included the embedding of entrepreneurial content into the freshman, junior, and senior design courses, impacting slightly more than 50% of the students in the School in this first year.

Initial plans for embedding innovation and the entrepreneurial mindset into the freshman and junior design courses at Baylor University, as submitted by the first of our two charter KEEN Innovators, included:

1. Entrepreneurial Lectures - In both freshman and junior design, there is sufficient flexibility in the course calendars to add between one or two lectures dedicated to the basics of entrepreneurship. These would serve to define terms, present concepts, and dismiss stereotypes associated with business.
2. Case Studies - In parallel with lectures on the basics of entrepreneurship, assign case studies for reading and discussion. This is a particularly important technique during the first few offerings of the course because the instructor will still be new to the concept.
3. Mock Environment (EGR 3380, "Design I", aka "Junior Design" only) - The structure of EGR 3380, Junior Design, is the simulation of a professional environment. Students are assigned in multidisciplinary teams of five and function as an engineering department or engineering company. Deliverable items at the end of the project include a functional prototype of a required device, a set of drawings sufficient to recreate the device, a presentation describing the operation of it, and a user's manual. This structure could be modified easily so that each team represents a startup company. Additional and/or alternative deliverable items might include a business plan, and a profit loss analysis associated with the manufacture of their device. Their final presentation could be altered to simulate a pitch to venture capitalists.
4. Personal Stories - Finally, carefully consider using personal stories of entrepreneurship from within the School of Engineering and Computer Science. Guest lectures and/or short descriptions of entrepreneurial work by Drs. Randal Jean, Walter Bradley, and the course instructors could be incorporated into pedagogically appropriate material. Personal stories and examples are always more impacting on students.

Our second KEEN Innovator has also taught Engineering Design I (Junior Design), Machine Design, and Engineering Design II (Senior Design), but in recent years has been regularly teaching the latter two Machine Design focuses on engineering analysis and the design and selection of machine components to meet specific requirements. Senior Design is the capstone course of the engineering degree plans (mechanical, electrical and computer, and general engineering) program, and it brings to bear all of the students' prior training to incorporate design creativity, engineering analysis, teamwork, budget management, and technical communication.

It is in the capstone course, Senior Design, that our second KEEN Innovator chose to integrate entrepreneurship concepts and skills into the student experience. The course is project oriented where students team up to solve a specific problem that is provided either from external industry or private sources, or internally from our faculty. The course is team taught by two to four instructors, who try to emulate a professional environment that leads students through steps such as problem definition, customer specifications, design creativity, engineering analysis, building

and testing of products, professional technical communication, teamwork within a management structure, and managing a budget.

Students must design, build, test, prove, and deliver a product to the customer. Recent projects have had, and planned future projects do have, the potential for technology transfer and commercialization. Examples of these projects include: a baseball field measurement and marking device, a patient lift system for hippotherapy clinics, wireless

light-emitting markers for motion capture systems, a mechanical horse for physical therapy, and

a portable touch-screen device for tracking chores and rewards.

Some of these project ideas are brought from external sources, and others are generated internally. All require further development before they could be brought to market, but so far we have not gone beyond the prototype stage. However, in some instances we are getting requests to produce more, and in two cases (of internal ideas) we have gone forward with invention

disclosures (including student co-inventors).

Senior Design is an appropriate course for entrepreneurial concepts because the students are graduating, and are already thinking of their future careers. One objective in integrating the entrepreneurial mindset into this course is the broadening of students' perspectives on how their creative ideas can be developed into a marketable product, with the intent that students see beyond just solving an engineering problem to get a grade or please a supervisor, but to think about the potential for commercialization of their products.

The structure of the Senior Design course is well-suited for integrating entrepreneurial concepts.

To begin, the students are already working on a project in a simulated professional environment, and student questions and class and team discussion can be guided to include the entrepreneurial considerations. For example, how would the team design this differently if it were to be manufactured in large quantities? How can the team increase robustness and reliability of the product? How can the team reduce the cost, and what is the cost effectiveness if the target production is few versus a target production of thousands? How could the team save cost by leveraging bulk quantities? What tooling would we need to produce these in large quantities?

How can our design be improved for increased customer usability and easy maintenance? How do we leverage existing manufacturing capabilities, existing material availability, and other such factors to save costs and streamline production?

In addition to discussions that naturally spring up while we are "on the go," it was envisioned

that some in-class time be used for short lessons or more directed discussions about

entrepreneurship. The synergy between engineering and entrepreneurism, the different methods for funding ventures, and the patent process and patent searches, as well as many other topics, would be investigated and discussed.

Challenges and Gaps

For both KEEN Innovators, much of the motivation and excitement about the KEEN opportunity was because of what they would learn and gain through their involvement. While both had some background with business plans and seeking venture funding, their experiences were not necessarily in the context of engineering or the transfer of technology developed through engineering design and production.

In both of their cases, their entrepreneurial interests had already begun to spill into the engineering design courses they taught, but both felt inadequately equipped to guide students and direct projects to more advanced levels. For example, what are the steps, the different models, the different paths, for taking an idea from the design and prototyping stage to market? What are, and how do you handle, the many issues related to licensing technology, engaging manufacturers, and getting the product into the hands of marketers and retailers? How do you fund such endeavors, and what are the pros and cons of different approaches?

In addition, both KEEN Innovators expressed a desire to increase their knowledge related to entrepreneurial content, and were both eager to learn more about how to share such knowledge with their students.

Feedback from the Innovators

The initial plan for the first year KEEN Innovators was two-fold. First, we would take them to the KEEN Annual Winter Conference, whose goal it is to expose other members of the faculty and administration of KEEN institutions to the goals of the Kern Family Foundation in general, and the KEEN in particular. Second, we would provide a one-day workshop taught by one of our network colleagues, Dr. Jonathan Weaver, Professor and Chair of Mechanical Engineering at the University of Detroit-Mercy.

The one-day workshop was the most effective training provided, according to both of our Innovators. Topics introduced in the workshop included:

- Engineering in Change

- Spelling Test
- Biomimicry
- Bisociation
- Trimming Technique
- Technology E-ship Case Studies
- Breakout: What can we do at Baylor University?

Preliminary Outcomes

One of the major classes where a KEEN Innovator has incorporated entrepreneurship principles is our senior design course. This is also a key course that is regularly assessed to support three of our ABET program outcomes:
(c) an ability to design a system, component, or process to meet desired needs;
(d) an ability to function on multi-disciplinary teams; and
(g) an ability to communicate effectively.

Student communication performance in senior design is assessed by the professors. Design performance is assessed by the professors as well as project sponsors (if there is an external sponsor). Students do anonymous peer assessment of how they work on teams. Team involvement is also assessed by the professors in charge of the course. Senior design is one of two courses that are used as the prime location in which to assess criteria (c) and (d). Criterion (g) is assessed through two courses, senior design and senior laboratory. We believe that by comparing results over time we will likely see an improvement in these three areas. With only one data point (spring 2009 offering of senior design) we do not yet have enough data to make firm conclusions.

Plans for the Future

Our second round RFP for KEEN Innovators has been awarded, with the result that the entrepreneurial mindset will continue to be integrated in the engineering curricula (ELC 3414, "Electronic Design", and ME 4396, "Analysis and Design of Propulsion Systems"). Additionally, we hope to be invited to submit a second-round funding request that would further expand our objective of putting innovation back into the engineering and computer science curricula by continuing to provide our faculty a chance to experience some of these new approaches themselves.

The need to innovate is a vital requirement not only in the rebuilding and sustaining our economy and in the training of our up-and-coming engineering and computer science professionals; it is also something we must learn and experience before we can teach effectively.

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