
AC 2011-734: ENGINEERING EDUCATION AND THE ENTREPRENEURIAL MIND

Cynthia C. Fry, Baylor University

Sr. Lecturer of Computer Science, Assistant Dean of the School of Engineering & Computer Science,
Baylor University

William M. Jordan, Baylor University

WILLIAM JORDAN is the Mechanical Engineering Department Chair at Baylor University. He has B.S. and M.S. degrees in Metallurgical Engineering from the Colorado School of Mines, an M.A. degree in Theology from Denver Seminary, and a Ph.D. in mechanics and materials from Texas A & M University. He teaches materials related courses. He does work in the areas of entrepreneurship and appropriate technology in developing countries. He also writes and does research in the areas of engineering ethics and engineering education.

Engineering Education and the Entrepreneurial Mind at Baylor University

Abstract

Our current economy is facing many new challenges, including the challenge of technological competition from other countries. Engineering educators face the challenge of how to motivate our students to become competitive in a global marketplace. 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. This paper describes our efforts to introduce the entrepreneurial mindset into our undergraduate engineering students, primarily through a program that is transforming our faculty.

We have completed two years of a program at Baylor University designed to help engineering educators teach innovation and become innovative in their teaching, and have received another grant to greatly expand it. This paper will present the background of the program, the assessment of the first two years 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

One of the keys to developing a successful entrepreneurially-minded engineer and engineering program is faculty acceptance of this subject and its integration into the engineering curriculum. Only then will students be exposed to these topics in a methodical, sequential nature. Only then will students see the importance of these topics in their future employment. Most faculty, however, have not had exposure to many of these topics in their educational or professional background. This is especially true of academics who have never worked in industry.

In the last two years, Baylor University's School of Engineering & Computer Science has designed, developed, and implemented the Kern Entrepreneurship Education Network (KEEN) Innovators program to help faculty learn the importance of the entrepreneurial mindset, not only in how they approach their vocation, but also in how they expose students to these same attributes. We discuss the program design, its initial implementation, challenges faced, lessons learned, and plans for the future.

In the last fifty years, the emphasis in engineering education has been to equip our students with the analytical tools thought to be needed for success in the workforce and/or graduate school. This is in contrast to the more hands-on educational model employed before the rapid industrialization seen during World War II.^{1,2} In Friedman's book, "The World is Flat," and Pink's book, "A Whole New Mind," although coming from rather different perspectives, both authors agree that the jobs calling for these skills can be done better and cheaper in other parts of the world.^{3,4} More importantly, they predict that American workers with a variety of right-brained skills will continue to find meaningful employment. Imagine a highly creative,

multidisciplinary team of professionals who can collectively recognize the complex patterns and opportunities in the global economy, and who can develop compelling strategies for capitalizing on these opportunities. Imagine a team of people with strong interpersonal skills, language skills, and knowledge of the cultural nuances between countries. Imagine a team of engineering professionals who are not only technically competent, but are also self-directed learners, capable of staying abreast of the rapidly changing technological landscape.⁵

These are the engineering professionals we need to develop for the new economy, but who can lead them in their educational journey if many of the engineering educators in American universities and colleges were educated themselves under the old paradigm? If engineering faculty only see their role as imparting “traditional” engineering topics to their students, the students will not have the opportunity, while in college, to develop these skill sets so desperately needed.

While ABET has fundamentally changed the emphasis of engineering education, it only begins to scratch the surface of what it means to be an entrepreneurially-minded engineer – an engineering professional who not only is technically competent, but also has developed a level of business acumen, is aware of their customer’s values and needs, and is ever mindful of the societal value of what they do as engineers and computer scientists. The key to developing the next generation of successful 21st century engineering professionals is faculty acceptance of the change in engineering education paradigm.

So the greater challenge is in convincing the engineering educator that change is necessary, given the precarious balance of the constraints existing in educational institutions, the criteria that must be measured to achieve and maintain accreditation, and the constant enlargement of the knowledge base. The second part of the challenge is in helping these educators to learn how best to integrate these realities into their approach to teaching. If faculty members do not adequately understand the fundamental changes occurring in the global economic landscape, as well as their importance⁶, these topics will not be incorporated into the curriculum and may even be actively denied their place in the curriculum development process. Many faculty members have not had exposure to these topics in their educational or professional background. This is perhaps truer of academics who have not worked in industry.

Through the KEEN Innovators program at Baylor University, selected faculty members who have shown an interest are exposed to ideas that can help them develop an understanding of the needs facing the U.S. today as it relates to the changing requirements for engineering success. Past publications have explored the beginning of the KEEN Innovators program, emphasizing integration of some of these skills in the various design courses.⁷ This paper will continue the discussion of the various faculty development programs and activities offered to those selected to be KEEN Innovators.

KEEN Innovators 2009 and 2010

In the first two years of the KEEN Innovators program at Baylor, we selected two new innovators each year. The KEEN Innovators were exposed to many different methods of integrating the entrepreneurial mindset into their courses. These opportunities included a one-

day workshop, conducted by one of our KEEN colleagues, Dr. Jonathan Weaver, Chair of Mechanical Engineering at the University of Detroit Mercy. The format of this one-day workshop started with several creative thinking experiments, and included discussions on a variety of ideation techniques such as biomimicry, bisociation, the trimming technique, and an in-depth presentation of a variety of “Intro to Technical Entrepreneurship Case Studies”, developed by Dr. Weaver, and available on www.keennetwork.com. The workshop wrapped up with a breakout session, where the Baylor participants were given an opportunity to discuss how these ideas and case studies could be integrated into their existing courses.

The Innovators also attended the Annual KEEN Winter Conferences, and had opportunities to participate in the exchange of ideas on how to integrate some of these “soft skills” into their courses through a series of regional KEEN conferences. They were awarded a summer stipend to help compensate for the time required to synthesize what they had learned and their implementation approach to their classes.

During our charter year of 2009, we solicited those instructors teaching the far-reaching design courses with the objective of exposing as many engineering and computer science (ECS) students as possible to the entrepreneurial mindset:

- Freshman Design (fall 2009) 206
- Junior Design (2009-2010) 80
- Senior Design (2009-2010) 75

So in our first year, of a total of 526 engineering students in the school, 361 of them, or 69% of them, were exposed to the entrepreneurial mindset.

During this first year, the Innovators had access to the KEEN network of 20 schools and their KEEN Fellows and associates. The one-day workshop facilitated by Jonathan Weaver gave the Innovators a “jump start” at how to introduce innovation and creativity back into the design courses. The 2009 Innovators also participated in the 2009 KEEN Winter Conference.

Through the continuation of the KEEN Innovators program in 2010, we added technical depth to our continuing innovations in the design sequence with the addition of our 2010 KEEN Innovators. Both Innovators had access to the same one-day workshop as the previous year’s Innovators had, and were also able to attend the 2010 KEEN Winter Conference. Dr. Kenneth Van Treuren has incorporating aspects of conceptual design into his senior-level Propulsion class during the fall 2010 semester, having his students walk the fine line of writing an RFP for an intelligence-collecting unmanned vehicle. Dr. Randall Jean has introduced the patent process in his Electronic Design course, helping students appreciate the importance of placing value on innovation throughout the semester.

Both of the 2010 KEEN Innovators have included new course objectives in their classes pertaining to innovation and creativity. These objectives can then be measured at the end of the semester to determine the extent to which the students developed an understanding of the concepts, in much the same way as the ABET criterion are measured.

KEEN Innovators 2011

In the 2010-2011 academic year we have been awarded funding to further our KEEN Innovators program, however, we have redesigned the selection and stipend process to increase our growth rate amongst the ECS faculty. Instead of awarding a \$5,000 stipend to two new Innovators, in 2010-2011 we will expand the program in the following way:

- Summer stipends available for 10 new Innovators for the following required components:
 - one-day summer workshop
 - Implementation plan developed and submitted, including assessment plan
- From the ten implementation plans provided, four will be selected for further funding:
 - Analysis of end-of-course assessment (raw data and analysis)
 - Travel to Annual KEEN Winter Conference

Part of this one-year planning grant will be to develop assessment measures for the learning objectives of this aspect of the courses through which students will be taught. We feel strongly that the seven key attributes/outcomes of an engineer, developed at the December 2010 KEEN Assessment meeting, and presented nationally⁸, need to be included in the ongoing assessment done on all of our classes. These outcomes are:

1. Effectively collaborate in a team setting
2. Apply critical and creative thinking to ambiguous problems
3. Construct and effectively communicate a customer-appropriate value proposition
4. Persist through failure to do what is needed to succeed
5. Effectively manage projects and apply the commercialization process
6. Demonstrate voluntary social responsibility
7. Relate personal liberties and free enterprise to entrepreneurship

We will continue to work with the KEEN this summer and fall on the deployment and assessment of the KEEN Assessment Program, and feel that this is a critically necessary piece in telling the story of the successes in the KEEN programs, including Baylor's KEEN Innovators program.

The Future of the KEEN Innovators Program at Baylor University

Another part of this year's efforts will be to research and collaborate on how best to present these topics in a new way, without repeating what has been done in the past. We will also address the future expansion of the program to include all ECS faculty, a required assessment plan, and the future inclusion of faculty from the sciences, where appropriate.

For the longer-term impact, as we reach a critical mass of engaged Innovators in 2011, our plan is to use this convergence of Innovators to allow us to gauge the best ways to incorporate entrepreneurial concepts in the entire curriculum, including those courses/programs with less obvious opportunities. Several possibilities include:

- bringing other faculty from STEM-related disciplines across campus into the KEEN Innovators program through the Technology Entrepreneurship Initiative (TEI) at Baylor; and

- Inclusion of other related areas, such as Law and Film & Digital Media, into the Innovators program through the TEI.

One of the challenges we face in the future is in how we can sustain the growth of the program in a way that makes sense, being receptive to the on-going changes facing our discipline, and being mindful of the right-brained characteristics that will bring the U.S. back from technological obscurity.

Summary

Throughout our country's short history, we have developed a work ethic that dictates the need to continuously innovate. In the challenge to educate engineers in a short four to four and a half years, we struggle with the ever-expanding knowledge base of engineering, the highly viscous rate of change in educational institutions, and the need to incorporate innovation and creativity into our existing coursework. As engineering educators we must leverage our strengths and opportunities so these concepts have a more prominent role in the curriculum. While challenging, it is critical that we become more creative in how we teach so that we can adequately train the future of engineering professionals to once again lead the world in innovation and creativity. The KEEN Innovators program at Baylor University is one of the many approaches we are taking to accomplish this objective.

References

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- ¹ P.C. Wankat, et al., eds. "The Scholarship of Teaching and Learning in Engineering." *Disciplinary Styles in the Scholarship of Teaching and Learning: Exploring Common Ground*, ed. Huber and S. Morreale, 2002, AAHE/Carnegie Foundation for the Advancement of Teaching: Washington, D.C.
 - ² M.S. Gupta, "Is Industrial Experience Necessary for Teaching Engineering?" *IEEE Transactions on Education*, Vol. 31, No. 1, February 1988.
 - ³ T.A. Friedman, *The World is Flat*, New York: Farrar, Straus, & Giroux, 2005.
 - ⁴ D.H. Pink, *A Whole New Mind*, New York: Riverhead Books, 2005.
 - ⁵ R.M. Felder, "A Whole New Mind for a Flat World," *Chemical Engineering Education*, 40(2), 96-97 (2006).
 - ⁶ E.D. Hirleman, E.A. Groll, and D.L. Atkinson, "The Three Axes of Engineering Education," *International Conference on Engineering Education*, Coimbra, Portugal, September, 2007.
 - ⁷ C. Fry, W. Jordan, G. Leman, B. Garner, B. Thomas, "Bringing Innovation and the Entrepreneurial Mindset (Back) Into Engineering & Computer Science: the KEEN Innovators Program," 2010 ASEE Annual Conference & Exposition, Louisville, Kentucky, June 20-23, 2010.
 - ⁸ D. Pistrucci, R. Kleine, D. Carpenter, P. Singh, "Assessing the Entrepreneurial Mindset in Undergraduate Engineering Education: New Methods and Emerging Practices in the Kern Entrepreneurship Education Network," NCIIA 15th Annual Open Conference, Washington, D.C., March 2011.