International Journal of u- and e- Service, Science and Technology
Vol.10, No. 2 (2017), pp.45-52
http://dx.doi.org/10.14257/ijunesst.2017.10.2.05

Integrating Entrepreneurship into Engineering Education

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Abstract

Negative economic growth, corrupt governments, and global financial crisis; have attributed to chronic poverty in diverse nations in the world. In fact, this has triggered the Arab uprising, labor strikes and daily common unrest in the west. There must be a solution and not empty promises of creating new jobs and getting people employed that governments have made for ages. To promote entrepreneurship for young generation and integrating these skills into the educational system is one solution. Entrepreneurship is the act of being an entrepreneur, being innovator and introducing new ideas in business. The effort to transform innovation into economic goods and forming new organizations is what we are discussing. The traditional way of engineering education which focuses on technical activities or issues associated with product, service and design has to be reevaluated to include entrepreneurship and business activities. This paper discusses the issue of entrepreneurial engineering education and its importance in economic development in higher learning institutions. Integrating entrepreneurship into engineering education is an imperative domain of technological development for the Muslims' world. The paper proposes general framework for integrating entrepreneurship into engineering educational system.

Keywords*: Entrepreneurship, Engineering Education.*

1. Introduction

Nowadays, many platforms are available online that provide freelancers' services; to name a few, freelancer.com, elance.com, and nabbish.com. Most of the freelancers on these platforms are highly qualified technical professionals who compete with each other for short- period projects posted by employers. For employers, the platforms are heavens for low cost technical talents.

The above case is also true for all fields of engineering. Routine engineering services have already been available for a while now from low cost providers around the world either online or on the ground. The leaders of the engineering profession around the world are convinced that innovation is of a central theme, and that engineering education should add value beyond just teaching technical skills. Of course those skills are important and required for the aspired engineers; however, they are not sufficient to face the challenges of the engineering profession today [3]. While the core of engineering, i.e. the process of design, build, test and iterate, will not change, we're witnessing an ongoing development on the way that engineers do their jobs; which reflects the challenges faced by the profession in response to the global economy and international marketplace. There is, and will be, a growing need for interdisciplinary and system-based approaches, demands for customization, and an increasingly diverse talent pool. Challenges will

ISSN: 2005-4246 IJUNESST

abound, but opportunities also will exist if engineering takes the initiative to prepare for the future [2].

2. Opportunities and Challenges Facing the Engineering Profession in the 21st Century

The Systems Perspective: In the past, scholars and scientists tended to have multiple specialties at the same time. At the Muslim golden ages, Ibn- Sina (also known as Avicenna) was a medical doctor as well as a famous philosopher; Al- Zahrawi was a surgeon and also considered as a biomedical engineer. That is because of the contribution he has made in inventing surgical tools that are still in use today. At the time, Complexity in knowledge discovery could be comprehended and managed by one or a few scientists, be it in engineering or other fields of knowledge. As time progressed, steady increases in knowledge have spawned new micro disciplines within different fields including engineering (e.g., microelectronics, photonics, and biomechanics). That has necessitated micro specialization. The increasing complexity, however, has risen up the need to integrate these disciplines into a whole, which requires a systems perspective [2]. Systems engineering is an interdisciplinary field that based on the principle of integrating different components and technologies using structured methodologies. It is the one in which diverse components are blended and harmonized in a larger theme. Achieving harmony between different components in a theme necessitates the need for new ways for doing engineering [2].

Working in Teams: The importance of adopting effective interdisciplinary team building strategies has recently been recognized by engineering professionals. These strategies have been assembled and developed through other disciplines such as business, psychology, and other human sciences. For engineering, effective multicultural team building is a critical success factor in a system- based engineering environment.

Customization: Competition in a global economy has made businesses use new marketing paradigms to survive. Customerization is a buyer-centric strategy in which customers participate in the design of the product they want to buy. This has risen up the challenge for engineers in addition to their technical skills, they need to possess people skills and interact with customers in efficient ways. The challenge is to create engineering workforce and business environment that can prosper in a mass-production less economy; it is to identify what engineers need to know and do in response to such economy [2].

3. The Engineer of the 21st Century: Aspired Attributes

"It seems to me that anyone who would call himself college educated —particularly anyone who would call himself a professional— should spend some time in close communion with the great souls, the great thinkers, the great artists, of our civilization. Most particularly, those engineers who would be leaders, those who would participate in the important communal debates should be acquainted with the thoughts, theories, and philosophies that constitute the foundations of our culture"

The Civilized Engineer, Samuel C. Forman

In this section, we would like to borrow some of the attributes that were aspired by the National Academy of Engineering (NAE) of the US, in their report ―The Engineer of 2020: Visions of Engineering in the new Century, 2004; these attributes are:

- Strong analytical skill: will remain one of the important attributes for engineers of today as well as for the engineer of the future.
- Practical ingenuity: these include the skills in planning, combining, and adapting,

- Creativity: as the complexity and diversity of technologies and systems grow in the 21st century, the importance of a creative engineer will also grow. This engineer will appreciate the growing importance of interdisciplinary interaction and cooperation.
- Communication: In the new century, engineers need to interact and communicate convincingly with different parties and to shape their opinions and attitudes. These include interdisciplinary teams, globally diverse team members, public officials, and a global customer base.
- Business and management: Engineers need to know how to manage and motivate their employees. They need to know how to get business running, but also how to survive and get a head of competion in a highly competitive environment like the one of the 21st century.
- Leadership: In preparation for business and management, engineers must understand the principles of leadership and be able to practice them in growing proportions as their careers advance. One of the most important qualities of a leader is a clear, inspiring vision. Muslim leaders should relate their visions to the creator of everything, to Allah. In this way, the leaders and followers strengthen their relationship with Allah, while practicing their everyday responsibilities.
- High Ethical Standard and Strong Sense of Professionalism: Engineers need to possess these qualities not only to become effective and authentic leaders, but also productive professionals. A Muslim engineer in particular needs to adopt high ethical and professional standards as it is about to what extent a good Muslim he has become, as the hadith of Prophet Mohammed peace be upon him stated: ―Verily Allah loves any one amongst you, who when he undertakes a job, carries it out with al- itqan (Professionally).
- Dynamism, Agility, Resilience, and Flexibility: Not only will technology change quickly in the 21st century, the social-political-economic world in which engineers work will change continuously. In this context it will not be this or that particular knowledge that engineers will need but rather the ability to learn new things quickly and the ability to apply knowledge to new problems and new contexts.
- Lifelong Learning: Since technical skills are no longer enough to be personally successful as an engineer, engineers need learn continuously throughout his or her career, not just about engineering but also about history, politics, business, and so forth.

4. Developing the Entrepreneurial Engineer: Benchmarking and identifying good practices

In this section we would like to highlight the experience of a world- class organization, which has successfully integrated entrepreneurship within its network of about 20 universities at the undergraduate level in the United States of America. This organization is Kern Entrepreneurship Education Network (KEEN), which is a collaborating group of U.S. universities that work to instill an entrepreneurial mindset in undergraduate engineering and technology students. KEEN's mission is to graduate engineers who will contribute to business success [5]. This mission is further clarified by KEEN's student outcomes; specifically, the engineering graduate of a KEEN university must possess soft skills as well as technical skills. These soft skills such as teamwork, creative thinking,

communications, and lifelong learning among others, are imperative attributes of an entrepreneurial engineer. KEEN emphasizes its efforts in undergraduate engineering students due to its philosophy that introducing entrepreneurship early is more effective and results in more created ventures.

4.1 What to Benchmark?

Subsequently, we try to identify good practices regarding the integration of entrepreneurship education in KEEN's universities by investigating three main areas:

1- The measures they use to instill an entrepreneurial spirit into their engineering graduates,

2- 2- Teaching methods and pedagogical contents they use to build an entrepreneurial knowledge and skills, and

3- 3- The measures they use to commercialize researches carried out within the network. These three areas will constitute the main points of our general framework for incorporating entrepreneurship within engineering education in Muslim countries.

4.2 Instilling an Entrepreneurial Spirit

KEEN universities have innovated many ways to instill entrepreneurial mindset in their engineering undergraduates. One of them has been suggested by two engineering professors from the University of Detroit Mercy [6]; who have developed a number of technical entrepreneurship case studies that are designed to be integrated into existing engineering fundamentals courses. These case studies are intended to provide engineering students with entrepreneurial role models and to show the would be engineers how those model engineers have capitalized their knowledge of specific engineering topic -covered in typical undergraduate courses- to create successful business ventures. The aim is to repeatedly showcase successful engineering entrepreneurs and to provide routine exposures to principles of entrepreneurship throughout the curriculum. Each case uses a set of PowerPoint slides with embedded video clips telling a documentary of the entrepreneur's story and it is designed to be covered in one lecture. Strong ties between the technical content of the case and the technical subject being taught has been developed [6].

It has been shown by Caroline Verzat and Rémi Bachelet [7] that the awakening of an entrepreneurial spirit can be achieved by hands-on project management experience during the first two years of an undergraduate program. They have noticed in an exploratory research that most newly trained engineers embarking the setting up of a business had been in a decisive leader position within their innovation project team. Also they have found that through pre-professional experiences such as internships, and activities in associations, the young student will progressively understand what he or she is capable of, which will help him or her to choose orientations for the future [7].

Two courses were developed within KEEN network that seem to be aiming at engaging the hearts and souls of the undergraduates before their minds. Both of them use innovative teaching methods and a team- based project that introduces students at early undergraduate years to the fun and innovative sides of product design and/ or realization.

The first course was developed in Worcester Polytechnic Institute. Its intent is to foster an entrepreneurial mindset in every graduate and to raise students' awareness that commercialization is part of the technological innovation process. The course is taught using several Harvard Business School (HBS) cases which is an unusual way of teaching introductory engineering courses. HBS cases are real life case studies distributed by

Harvard Business School Publishing, and are developed in all media format including text, videos, and audio. They cover all Business and management areas of study such as marketing, finance, sales, etc. Specific HBS cases were selected to represent each functional area (for example: marketing) grounded in either Innovation or Technical challenge. Students are given a team project that focuses on developing an innovation plan. Students teams, comprised of about five students each, are asked to develop an innovation plan to a specified problem. The students suggest a solution to the specific problem and then describe how they would realize it [8].

The other course which was developed in Santa Clara University, implements a stock market concept into an engineering product design course. It uses a project-based learning activity. The team-based course project was developed to serve as a fun and engaging mechanism for encouraging strong student performance throughout the duration of an eleven-week course [9]. Also, it is worth mentioning that creating an entrepreneurial culture in a university can be an accelerating factor for the integration of entrepreneurship into its educational system. This culture can be created by many ways; including for example creating an entrepreneurship club for the students, and starting a monthly speaker series [10].

4.3 Building an Entrepreneurial Knowledge and Skills:

An entrepreneurial knowledge can be built through Curricular, Co-curricular and Extra-curricular activities. Curricular refers to those activities which take place inside the classroom, such as courses, modules and case studies. Co-curricular activities are the exploratory opportunities that take place outside the classroom and are related to the subject being taught in the educational institutions, such as workshops, seminars, and projects. Extra-curricular activities are the experiential opportunities that take place outside the classroom and may also take place outside the educational institution, such as business plan competitions, technology competitions, and internships [11].

Maryland Technology Enterprise Institute (MTECH) of the University of Maryland, one of the KEEN universities, has implemented all above strategies to build the entrepreneurial knowledge of their engineering and technology graduates. They have created a living-learning entrepreneurship and innovation program for freshmen & sophomores and also have another living–learning program for senior undergraduates, in addition to the young scholar' summer program for high school students and postgraduate & professional certificates in technology ventures and innovation. For the living component of the living-learning Honors academic programs all students reside in an exclusive program residence hall for two years. Through company creation, impact seed funds, courses, seminars, workshops, competitions, on-site coaching and mentoring, and entrepreneurial internships, students are part of a special experiential learning model. The academic component of the Program includes four courses totaling nine credits, with all students enrolling in one course per semester for each of their four semesters in the program. A core goal of the Entrepreneurship and Innovation Program is to infuse students with that knowledge and its accompanying skills. The mission of the living-learning programs is to foster an entrepreneurial spirit, create a sense of community and cooperation, and develop ethical leaders [12].

4.4 Research Commercialization

An entrepreneurial research university is the one in which research and the technology developed within is commercialized. Research commercialization can be in the form of startup, corporate venture, or via license transfer through the university's technology transfer office (TTO) [13]. If the technology developed is realized into unique products that customers will purchase, satisfying a vital market need, the university's

commercialization efforts is in the right track. However, engineers tend to neglect the essence of a successful business which is delivering benefits to customers which involve marketing knowledge and market research [14]. A business focus based on technology is often called a technology push because of its reliance on the new technology to push customers into a new market. Engineers, especially, are likely to have ideas for products never before imagined which require huge efforts in marketing and educating people about the benefits of the new product and ultimately convincing them to buy it. This delays the profitability of new ideas that have no or little concerns of the market. A business focus based on market need is often called market pull because of its reliance on the market's desire for a specific benefit to be met through an expansion of state-of-the-art technology. In market pull, the customers are ready and you must deliver the technology. In technology push, on the other hand, the presence of customers is questionable even if you can deliver the technology. The key to launching a successful technical start-up is to make maximum use of any proprietary technology that can be developed while, at the same time, focusing on market opportunities. This is called a market- and customer-driven technology-fueled strategy [14]. Following is the experience related to the implementations:

4.5. Product Realization Process (PRP) into engineering capstone courses offered through the Innovation Center at the University of Dayton School of Engineering- a KEEN member university, in an effort related to research commercialization, and where industry sponsored team design projects feature an emphasis on innovation, entrepreneurship and developing business. PRP includes determining the customer's needs, developing specifications, generating conceptual designs, and designing the final product as well as its support processes (fig. 1). PRP methodology had been integrated into the curriculum using the industry sponsored projects. Those projects have two main objectives: 1- to develop a prototype of the design, and 2- to write a business plan that can be used by an entrepreneur to seek funding and perhaps start a business [15].

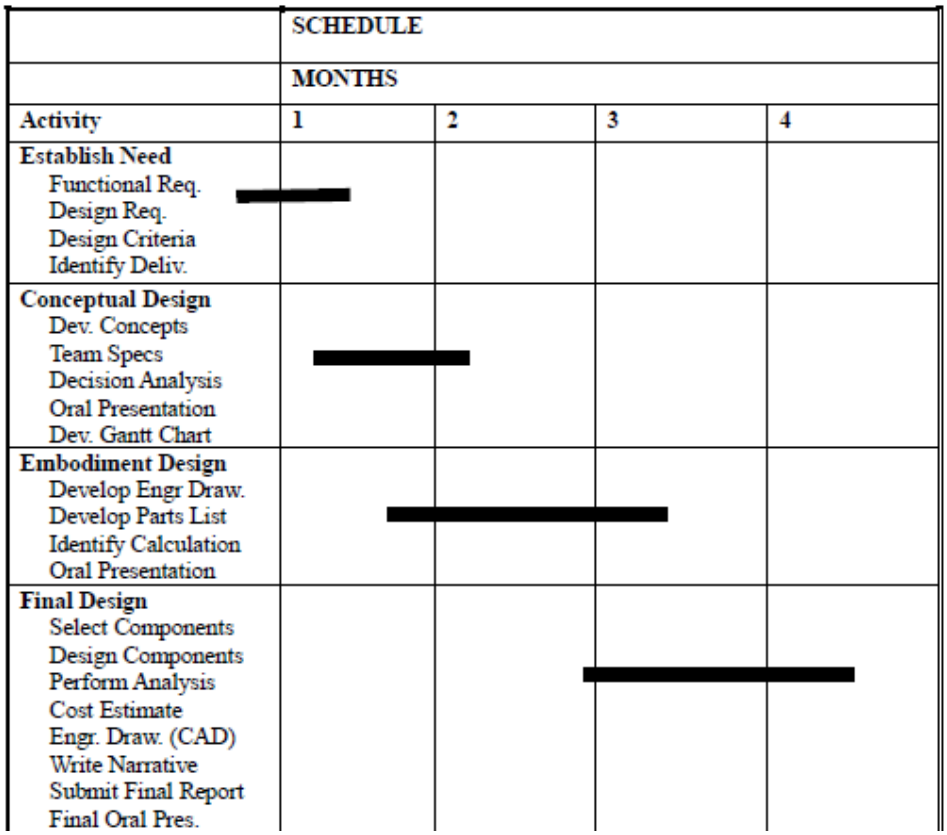

Figure 1. Gantt Chart Product Realization Processs

5. Conclusion

By benchmarking the case of Kern Entrepreneurship Education Network (KEEN), a general framework has finally emerged. To integrate entrepreneurship into engineering education in the Muslims countries need to instill an entrepreneurial spirit by building an entrepreneurial culture within the engineering faculty and students, developing entrepreneurial engineering role models, and acquiring early hands-on experience by involving undergraduate students into projects or providing them with entrepreneurial internships. Build an entrepreneurial knowledge and skills, through Curricular, Co-curricular and Extra-curricular activities. Research commercialization, by incorporating Product Realization Process ―PRP in the engineering design courses', and emphasizing a Market-driven, technology-fueled commercialization strategy.

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