Engineering engineering education for economic development

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Introduction - In the *World is Flat*, author Tom Friedman [1] suggests the world is in its third wave of globalization, one that is governed by people and communications. He states that the flattening of the world happened at the dawn of the 21st century; and that countries, communities, individuals, governments and societies can and must adapt to the challenges that this "flat world" presents. Thus, globalization is making both developed and developing countries think about effective and efficient strategies that will advance their economies and social development. Many countries around the world have made significant strides in the past 10 years in laying the foundations upon which market economies and democratic societies can flourish.

If technology and knowledge form the basis for meaningful economic development, given that globalization is radically accelerating the pace of change and raising the long-term stakes, it is clear that success in knowledge-based economies depends largely on the capabilities of people who are credentialed in meaningful and consistent ways. Further, the kind of knowledge countries need to develop is key: first, literacy of the general population, and then educating problem-solvers who can build the technical infrastructure for sustainable change. *Engineers are the ideal problem solvers.* When you consider that economic studies conducted before the information-technology revolution show that as much as 85 percent of measured growth in U.S. income per capita was due to technological change [2], a strong case can be made for seeing engineers as the key knowledge workers for capacity building and sustainable economic growth in emerging economies.

It follows, then, that to effectively compete in the knowledge-based economy, developing countries must invest in producing a large enough pool of high-quality and accredited engineering graduates. Both the United Nations Educational, Scientific and Cultural Organization and the World Federation of Engineering Organizations are actively engaged in technical capacity building in developing countries [3].

The Imperative and Challenges to Innovate and Reform Engineering Education - High-quality and pertinent engineering education, and quality-assurance mechanisms are imperatives for creating a knowledge-based economy. Engineering education must respond to local challenges as well as global opportunities. To innovate and reform engineering education, a country's educators need to understand what an engineer is, and what skills and competencies s/he must possess. Their education and professional development is not only about knowledge, but also about skills, values and competencies. Engineers must not only be knowledgeable about science and technology but also have the skills, competencies and values to address problems and opportunities in effective and creative ways.

Higher education, in general, is responsible for formally preparing the next generation of business leaders, technical professionals, government officials and educators. Engineering education, in particular, plays a central role in our increasingly technology-based societies. The education of engineers must prepare them for the multi-disciplinary nature of the problems they will face.

The need to innovate and reform engineering education is vital and undeniable. In the United States, for example, prestigious organizations like the National Science Foundation (NSF), the American Society for Engineering Education (ASEE) and the National Academy of Engineering (NAE) have reported on the growing need for change in engineering education [4, 5, 6]. Sweeping changes in the context for engineering accompanied by significant changes in the challenges offered by the engineering workplace bring urgency to the need for broad change in the education of engineers. In Europe, Siemens has undergone a massive understanding of engineering skills needed [7]. They conclude that while fundamental technical knowledge learned at the university level takes center stage during the career entry phase, other skills that are difficult to document are decisive for further advancement over the long term and should be fostered as early as possible in the curriculum.

But herein lays the problem: Engineering education has not traditionally concerned itself with the development of skills and competencies needed in the job market and workplace. According to Richard M. Felder, co-director of the U.S. National Effective Teaching Institute, "We're teaching the wrong stuff [8]." He argues that since the

1960s, the United States has concentrated almost exclusively on equipping students with analytical (left-brain) problem-solving skills, and that a) most jobs calling for those skills can now be done better and or cheaper by either computers or skilled foreign workers (and if they can be, they will be), and b) American workers with certain right-brain skills will continue to find jobs in the new economy. (For example, researchers, designers, entrepreneurs as well as other self-directed people, and people with strong interpersonal, cultural awareness and language skills.) Felder questions whether the U.S. education system is helping students develop the attributes they will need to be employable in the coming American and global engineering job market. The case of the US may be the situation in other regions of the world as well.

Furthermore, critical issues like research scholarship being recognized and rewarded over teaching, poor or inexistent industry-university relations, education centered on the teaching rather than on the learning experience, unawareness of the role of higher education, especially science and engineering, and innovation for developing knowledge economies, little or no resources available for curriculum innovation, among others, hinder the effective and efficient engagement of innovation of engineering education.

Possible Roadmap for Innovate the Engineering Curriculum to Better Respond to the Needs of a Globalized World - While there could be many ways to approach the challenge of reforming/innovating the engineering curriculum to better respond to the needs of a globalized world [9]. Some may stem from individual efforts (a professor who wants to excel as a teacher in the classroom), or from a group of faculty challenged to address some of industry's needs (as the case of the Learning Factory, a program developed by an university-industry partnership and aimed to integrate design, manufacturing and business realities into the engineering curriculum [10]). Nevertheless, here's a possible roadmap to consider.

First, it is key to align the mission, vision and strategies the University, the College of Engineering, and the particular engineering program. Universities, engineering colleges and engineering programs have a role, a mission to fulfill in the region/country where they reside. The role of developing the human resources to address local and global needs has to be aligned across the university and understood by all stakeholders (faculty, students, administrators, employers, community in general). Thus, strategic plans at campus, college and departmental levels need to be in consensus. **Second,** departmental strategic plans should include the definition of the engineering graduate profile. What kind of engineering skills, values, competencies are needed in an engineering graduate? This profile should be discussed with employers and other important stakeholders. Once this 'vision' of the graduate is defined, then, the **third** and most important step follows: how to develop/reform the curriculum and build in experiences for students to acquire the necessary knowledge and skill set. Student learning outcomes need to be defined (at the program and course level), teaching/learning classroom activities to ensure development of outcomes need to be defined (lectures, active learning and hands on activities that provide the real life engineering experience across the curriculum), and an outcomes assessment strategy needs to be crafted to validate outcomes (assessment tools and rubrics). **Finally,** evaluation of program goals and outcomes data should be shared with all stakeholders for effective process re-engineering.

This roadmap requires several important elements to be successful. One is building and nurturing win-win industry-academia relationships to promote collaboration. Another element is recognizing and addressing the fact that professors need to learn one of the basic dimensions of their job: how to teach in ways that students learn. And finally, a systematic and continuous quality enhancement culture needs to be top priority of academic institutions. Resources are limited and global competitiveness is a fact, thus, it is imperative to ensure engineering education is effective and efficient in achieving its goals.

Conclusion - Engineering and engineering education are closely linked to globalization and economic development. Engineering education that focuses on outcomes and on producing engineers that society, regions, nations and the world need is an imperative, one that countries committed to bettering the lives of their citizens must address. Universities need to engage in a serious dialogue with all stakeholders to address the challenge of curriculum innovation/reform to better address the needs of a globalized world.

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