Engineering Education in the 21st Century: Roles, Opportunities and Challenges

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ABSTRACT

The World has faced a wide myriad of problems for many centuries, the list being quite similar today. Almost all of them have - in some way or manner - to do with engineering and engineering solutions. These problems and the fact that we live in a highly communicated, 'globalized"globe, requires new sets engineering capacity, competencies and professional skills to address them as well as to furhter enhance technology and innovation as critical foundations to develop and sustain knowledge economies. Engineering education has a very importat role in society, bridging the gap between the world of today and education and addresssing local, regional and global challenges. This paper describes the challenges engineering and engineering education faces in the 21st Century as well as describe the role and opportunities engineering educators have to respond to these challenges. world.

Keywords: engineering education, globalization, curriculum innovation, professional skills, assessment

1. INTRODUCTION

Across history, there have been many reports and publications that describe the world's major problems. The list usually includes: Population, water, food, energy, health, environment, terrorism/conflict,climate change and sustainability. Most if not all of these problems have had, has or will have an engineering dimension (creating, solving, involving). A most recent hihgly quoted report focused on engineering problems publsihed by the US National Academy of Engineering lists fourteen engineering grand challenges (NAE, 2008) all, if not most of them, again related to engineering, technology and science, namely:

1. Make solar energyeconomical
2. Provide energy from fusion
3. Develop carbon sequestration methods
4. Manage the nitrogen cycle
5. Provide access to clean water
6. Restore and improve urban infrastructure
7. Advance health informatics
8. Engineer better medicines
9. Reverse-engineerthe brain
10. Prevent nuclear terror
11. Secure cyberspace
12. Enhance virtual reality
13. Advance personalized learning
14. Engineer the tools of scientific discovery

The list seems unsurmountable, yet, humankind cannot survive if it does not address these problems with urgency and effectiveness. Solving these problems will require, as Stanford University President John Hennessey says: "*deep collaboration and intensive investment.*"

1.1 OTHER WORLD CHALLENGES

In addition to the grand challenges listed above, the world of today and tomorrow confronts other challenge an ever changing technology landscape and information, knowledge production, the result of faster, efficient and new modes of communication and interconnectednes. The follwing chart demonstrates instant golobal internet connections, which demonstrate, the world can communicate constantly across space and time.

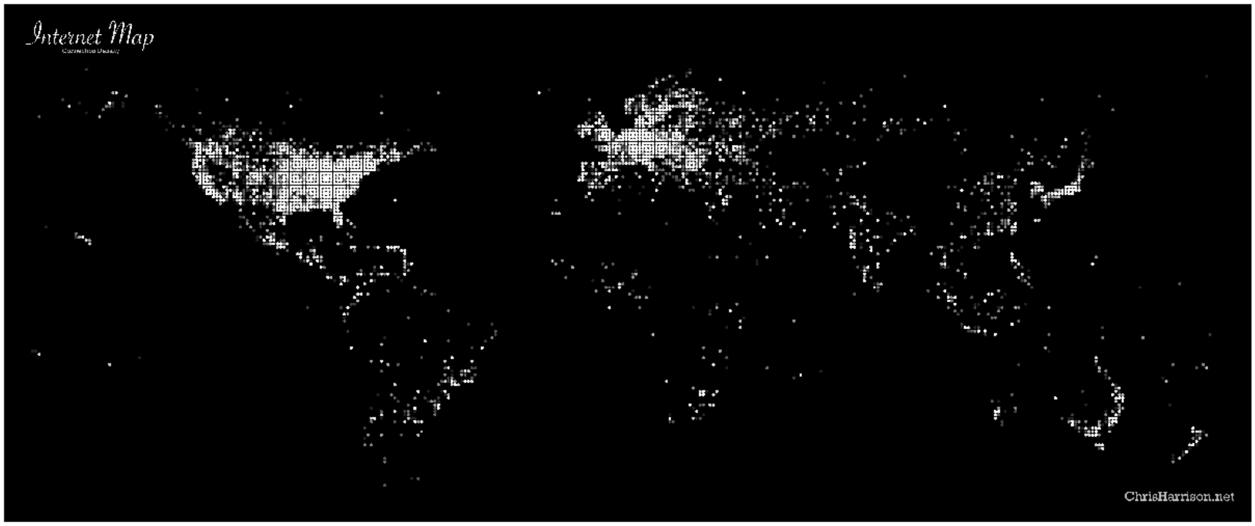

Figure 1: Instant Internet Connections (Source: http://www.chrisharrison.net/projects/InternetMap/)

This world interconnectedness, or 'flatness' as Thomas Friedman so brilliantly describes in his book (Friedman, 2007), the lowering of trade and political barriers and the exponential technical advances of the digital revolution have made it possible to do business, or almost anything else, instantaneously with billions of other people across the planet. In other words, we are facing a new world order, where new communication schemes have allowed the development of new business models (outsourcing, near sourcing, off-shoring, etc), which in turn, are requiring a new set of professional skills and competencies in the workforce, and of course, in university graduates.

The new professional not only needs to be knowledgeable in his/her own discipline, but also needs a new set of soft, professional skills and competencies.

But, what are these skills? There are many engineering professional societies' surveys, accreditation criteria, which have listed the engineering professional skills and competencies of the engineering graduate. Nevertheless, what the new world order and local/regional challenges require are quite novel.

Using an exciting combination of insights from foresight as well as systems and design thinking, Bob Johansen, President and CEO of the Institute for the Future Johansen (Johansen, describes the essential skills leaders must use to thrive in a world of volatility, uncertainty, complexity and ambiguity. In this world, he states, there will be danger as well as opportunity, thus leaders must learn new skills to address these and make a new future. Most of the skills he envisions for the 21st century technology professionals described in Table 1 do not yet appear in the dictionary!

The critical questions are: Are universities and colleges of engineering around the globe preparing the engineering/technology professional with the required skills? Are they aware of the need to develop these and actively responding by innovating curricula and the learning experience? Or does it look like the gap between the professionals universities are graduating and the needs of society and private/public enterprises is wide open and roadmaps to close it have yet to be created? What can higher education and engineering education do to address this gap, this opportunity to better serve society?

The answer to these questions is critical, urgent and unavoidable by all stakeholders involved.

1.2 WHAT IS GOING ON AROUND THE GLOBE?

As a result of the world's interconnectedness, new and successful business models and strong leadership and multi stakeholder alignment, developing countries and regions have realized that giving priority to knowledge and knowledge management will enable their economies faster to be able to globally compete. They are making significant investments in science and technology, innovation and ITC infrastructure. Many countries are following the pointedly suggestions of the World Bank Institute to develop knowledge economies (WBI, 2007), namely: education and training; ICT infrastructure, policies, and innovation/R&D. Clear examples of how countries are following these guidelines with success (of course, before the global financial situation of 2009) are:

- **Singapore -** the ‘economic miracle of the Asian region, with its focus on innovation, and IT infrastructure and government policies
- **Ireland –** transitioned from a poor, largely agricultural country whose young people were leaving it has become one of the most dynamic knowledge-based economies in Europe investing in education and bringing foreign investment.
- **South Korea –** which evolved to become one of the most vibrant countries in the region… a manufacturing powerhouse that has virtually eradicated poverty, malnutrition & illiteracy and finding its place in the global economy.

Table 1: Technical Leaders 21st Century Skills (Johansen, 2009)

Skills	Description
Mobability	ability to work in large groups; talent for organizing & collaborating with many people simultaneously
Influency	ability to be persuasive in multiple social contexts & media spaces; understanding that each context & space requires a different persuasive strategy & technique
Ping Quotient	responsiveness to other people’s requests for engagement; propensity & ability to reach out to others in a network
Multi-Capitalism	fluency in working with different kinds of capital: natural, intellectual, social, financial, etc.
Protovation	fearless innovation in rapid, iterative circles
Open Authorship	creating content for public consumption & modification
Emergensight	ability to prepare for & handle surprising results & complexity
Longbroading	thinking in terms of higher-level systems & cycles
Signal/noise	filtering meaningful information, patterns & commonalities from massively multiple streams of data
Cooperation Radar	the ability to sense, almost intuitively, who would make the best collaborators on a particular task.

Nowadays, Brazil, Russia, India and China (“BRIC” countries) are capturing the world news with their economic development achievements. For example, en August 15, 2010, China surpassed Japan as the second world largest economy (Barboza, 2010).

> “*China is still a developing country. It has a lot of room to grow. And China has the biggest impact on commodity prices — in Russia, India, Australia and Latin America.”*
>
> *~ Wang Tao, economist at UBS in Beijing, 2010*

China and other countries are capitalizing on their resources and people to compete, recognizing the relationship between education and economic strength, just as the US and other developed countries have (See Figure 2). In the US states where education attainment is high (Massachusetts, New Jersey, Connecticut, Maryland), the per capita income is high as well.

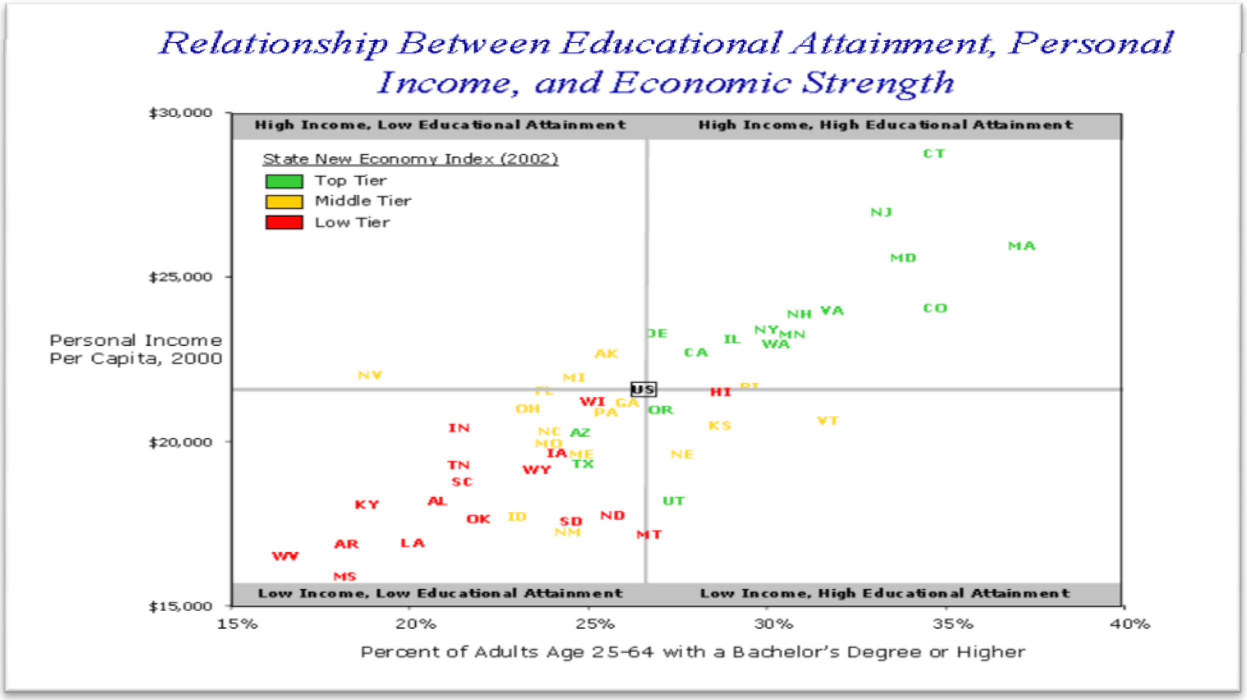

Figure 2: Relationship between the education levels of the population and per capita personal income (2009)

1.3 GLOBAL INVESTMENTS IN SCIENCE AND ENGINERING TALENT AND INNOVATION

In addition to capital, labor and land, knowledge is becoming a primary factor of production. In fact, many economists now argue that knowledge has become the most important component of production. The belief is that a knowledge economy will lead to improved quality, reduced costs, better response to consumer needs, and innovative products. Since knowledge resides in human resources, talented individuals are key to start the virtuous cycle that catalyzes economies.

The direct relationship between science, engineering/technology, innovation and economic development and sustainability is reported in the OECD Science, Technology and Industry Scoreboard (OECD, 2007, 2009). Countries like China, Korea, Sweden, Germany, and Finland are producing science and engineering graduates show healthy economies. And those that are investing significant amounts of their GDP in R&D and innovation are world economic leaders (Sweden, Finland, Japan, Korea, and Switzerland). The number of doctoral graduates, another key another indicator, shows that this talent trained to conduct research, invents solutions and contributes to the diffusion and use of knowledge and new business creation.

But unfortunately, science and technology investments and the number of science/engineering graduates do not necessarily mean quality or obtaining desired outcomes. Evidence points to the fact that the world's most valuable resource - a well qualified talent pool - is getting harder and harder to find. In fact, finding talented people is the single most important managerial preoccupation around the globe, according to a 2007 McKinsey survey.

Why is qualified talent difficult to find?

One possible reason may very well be because there is wide gap between what universities are producing and what companies need (Frymire, 2006; McKinsey 2008). It appears that the skills and competencies of university graduates are not aligned with the needs of the public and the private sectors. New university graduates indicate a country's capacity to absorb, develop and diffuse knowledge and to supply the labor market with highly skilled professionals. Results from the 2008 McKinsey survey of 83 worldwide executive interviews demonstrate a very low hiring rate in engineering and other professions. For example, if executives had 100 engineering positions to fill, they could hire only 13, 10, 25 and 10% of the engineers in Brazil, Russia, India and China, respectively. This could be due to many factors, but most certainly, related to out-dated curricula and lack/poor development of the skills and competencies needed in the workforce are certainly a strong factor, as stated in section 1.1.

The following question arises: Are traditional curricula preparing students well for their professional challenges?

The overwhelming response across the world is, no (Becker 2009). While working techniques, teamwork, methods/systems know-how, hands-on know how, communication/presentation, foreign language, negotiation and leadership skills are considered very important/important for the job, they are not considered as well taught in the university. There's a clear disparity between knowledge taught at universities and know-how required at the workplace.

Faced with this serious gap between, what can engineering educators do? The answer to this question is URGENT, CRITICAL and UNAVOIDABLE. For every day that goes by, society loses and nobody wins.

2. HOW CAN ENGINEERING AND ENGINEERING EDUCATION RESPOND AND ADDRESS LOCAL, REGIONAL AND GLOBAL CHALLENGES?

If technology and knowledge form the basis for meaningful economic development, and, 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. Furthermore, 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 (US NAE, 2005), a strong case can be made for seeing engineers as the key knowledge workers for capacity building and sustainable economic growth in emerging economies.

Thus, one can safely conclude that engineering and engineers are key to developing and growing knowledge-based economies. For no profession unleashes the spirit of innovation like engineering, few professions turn so many ideas into so many realities and few professions have such a direct and positive effect on people's everyday lives.

But engineering is a demanding and tough discipline. It requires intensive discipline and motivation and hard work. And in view of technology industry executives, it also requires more than textbooks, exams and theories.

> *"…for students to succeed as engineers, they must acquire skills that go far beyond theories, simulations and exam-taking... there is absolutely no substitute for the hard edged technical and business skills that are required to bring products and projects to market."*
>
> *~ Bernard M. Gordon, founder of NeuroLogica Corp., founder & former chair of Analogic Corp., and co-founder of Epsco Inc.*

So, what can engineer education stakeholders and leaders (deans, faculty, students, administrators, industry, government agencies, professional associations and others) do to reduce this enormous gap? The author suggests five (5) principal actions, namely:

1. Innovate, reform the engineering curriculum AND the learning experience
2. Focus on learning (not on teaching)
3. Foster creativity and innovation across the ecosystem
4. Implement continuous assessment and accreditation to drive excellence

5. Educate the engineering professor of the future

2.1 INNOVATE, REFORM THE CURRICULUM AND THE LEARNING EXPERIENCE

High-quality and pertinent engineering education are imperatives for creating a knowledge-based economy. Engineering education must respond to local challenges as well as global opportunities.

During the past 10 to 15 years there have also been significant amounts of resources spent worldwide innovating engineering curricula. In the US for example, some of the most prominent initiatives occurred during the mid 90's when NSF funded the Engineering Coalitions; for example: www.gatewaycoalition.com; www.synthesis.org ; www.succeed.ufl.edu) . These focused primarily on engineering curricula innovation, integrating outcomes assessment, using complementary technology and implementing new learning strategies. One of the authors of this paper - together with colleagues from Penn State University, the University of Washington and Sandia National Labs - also participated in a somewhat smaller but successful partnership called the Learning Factory, which received the US NAE Gordon Prize in 2006 for innovation in engineering education (Lamancusa, et al, 2008). Although these efforts were successful, they have not permeated the engineering education ecosystem the way the sponsors and participants thought they would. The engineering education culture – the model for training the next generation of engineers– is still the same.

Notwithstanding the current global economic crises, the fact remains that the economic progress and achievements of US and many other nations are rooted in their science and engineering talent. Why, then, has the engineering education model not evolved at the pace that science and technology have? How has top-tier science/engineering developments continued if students are not appropriately prepared? The workplace demands new engineers to be technically qualified, flexible, and dynamic thinkers, but their classrooms are not necessarily and systemically supplying them with these tools.

Perhaps the lack of attention to the educators themselves is the key oversight in this system. Evidence of this perceived lag can be seen in Figure 1. About 50% of industry and academia respondents in an Engineering 2020 survey dissent from the assertion that the current undergraduate engineering education is sufficiently flexible to adequately meet the needs of 21st century engineers.

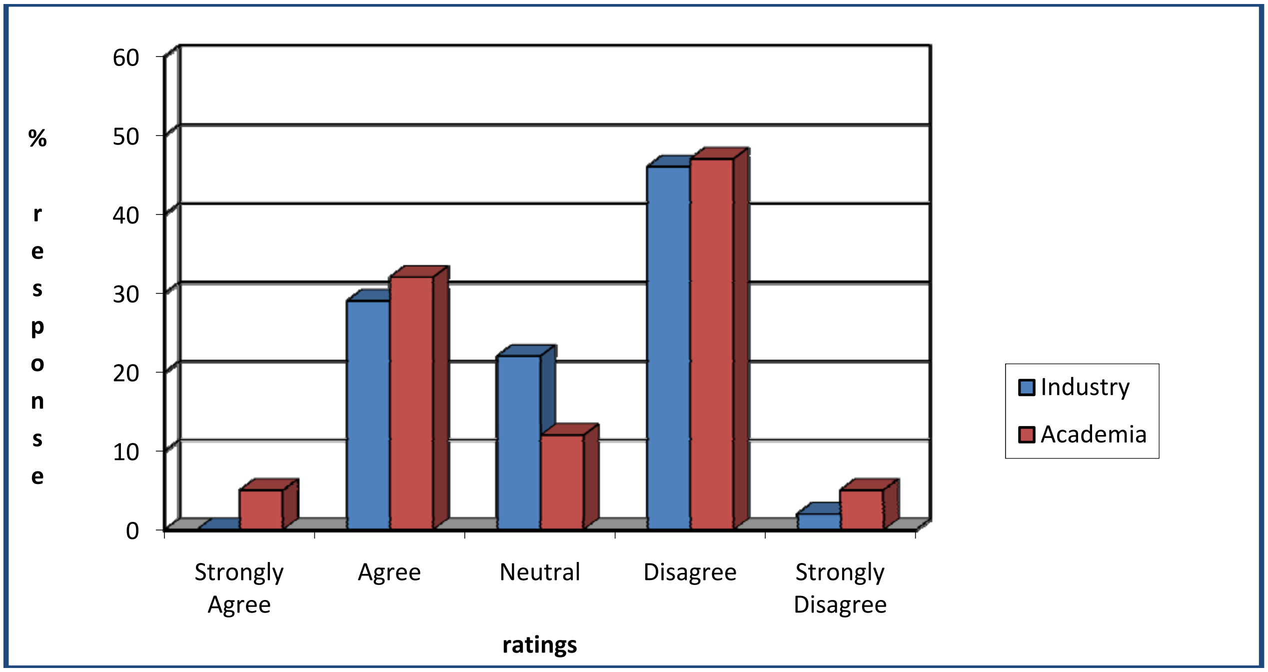

Figure 3: Responses to Question: "Current undergraduate engineering education is sufficiently flexible to adequately meet the needs of the 21st century engineers" (US NAE, 2004)

Therefore, the author strongly believes that in order to innovate and reform engineering education, the engineering education leadership requires a systemic, integrated approach. Why not apply the engineering problem solving approach engineers are experts on, to innovate the curriculum? Engineering educators could take the following steps:

1. Define educational objectives/desired outcomes
2. Plan the education process (content, skills, competencies, experiences)
3. Measure outcomes (outcomes, learning, process)
4. Share results/discuss with stakeholders
5. Make decisions (to improve, not punish)
6. Re-engineer/re-form

One first critical action to be undertaken in this process is to understand the elements, components and variables that characterizes the 'educational ecosystem'.

The author's description of a university, college or engineering program is similar to a chemical reactor: a system existing in a location/city/country/region and which mission is to provide educated citizens, generate/augment the pool of knowledge and serve its community (the three-pronged mission of universities). It receives students from the secondary system of education with certain skills and competencies and through its education/experiences processes, generates outcomes of value to society. Each university, college or program has 'unique variables' that define the system and help achieve desired outcomes (like a chemical reactor). The unique combination and value the system places in these variables gives the distinctive nature of the program. These 'variables' include curriculum, faculty qualifications, student experiences, textbooks used, labs and infrastructure, and others.

So, the Chemical Engineering (ChE) program at the University of Puerto Rico at Mayagüez is not equal to any other ChE program around the world. Why, because it exists only in Puerto Rico, serves the Puerto Rican society (although its graduates are recruited from several parts of the world!), and the institution has certain specific goals and values that makes it one of a kind. Yes, there may be things that are somewhat the same among various institutions (courses, textbooks, credit-hours, etc), yet each one has distinctive attributes.

In order for a university or engineering program to be of value to society, it has to understand its needs. What are the city/country/region economic development and human resources needs now and in the future? Where in the value chain the city/country/region wants to be in the future (innovation, manufacturing, marketing, all)? What are the technology niches it wants to nurture or develop? Once these questions are answered by all stakeholders in consensus, the program can then define the skills, competencies and values of its graduates, which in turn will define curricula AND student experiences needed to achieve educational goals.

A key step in this process is the definition of the engineering graduate profile, the skills and competencies s/he must possess to be successful as an engineer. Engineers face problems as a way of life. 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.

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 (Felder, 2006])” 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.

Another important element in this process understands the principal stakeholder: the engineering student. The 21st century student is creative, mobile, collaborative, multi-tasking and producer. He/she was born with technology and uses it freely. Educators should understand their motivations, how they spend their time, their challenges, their expectations for the future and their perceptions and expectations of the education they are receiving.

For engineering education to be effective, it needs to innovate both the curriculum AND the learning experience taking into consideration the needs of society and the learner.

2.2 FOCUS ON LEARNING (NOT ON TEACHING)

Few engineering professors are taught how to teach (in fact, few higher education professors, in general, are educated in pedagogy). Adults have special needs when it comes to learning and few higher educators are aware of them. Only few understand that humans have preferred learning styles and that professors like to teach the way they learn. At most, what engineering professors start their academic careers, they replicate/adapt the teaching style of their professors, which resembles an 18th century classroom. But teaching is too complex and too important a profession to let people do it with no training or experience (Felder, 2004). According to Felder, most engineering instruction in the past few decades has been heavily biased toward intuitive, verbal, reflective, and sequential learners, although relatively few engineering students fall into all four of these categories. The result is that most engineering students are taught in a manner at least partially mismatched to their learning styles, which could hurt their performance and their attitude toward engineering as a curriculum and career.

For engineering education to be effective it has to focus on the learning not on the teaching. Educators need to integrate diverse classroom (and out of classroom) techniques, like cooperative learning, active learning, visuals, etc. to address the learning styles of all the students.

2.3 FOSTER CREATIVITY AND INNOVATION

> *"Innovation is the specific instrument of entrepreneurship… the act that endows resources with a new capacity to create wealth." Peter Drucker*

Innovation (and its outcomes) is one of the foundations of knowledge-based economies. Innovation is driven by processes that succeed only where organizational conditions foster the transformation of knowledge into products, processes, systems, and services. In order to catalyze and sustain economic development, innovation has to be ingrained in the culture of people; it has to be a mindset that drives people to make better everything around, including personal life all the time. Innovation also allows education stakeholders to be open and accept others' ideas. For innovation to occur and to have economic and societal impact, all sectors of society have to be involved to both solve local problems and be globally competitive.

According to the World Economic Forum ((2008), the 'magic formula' for innovation is:

- 2 universities (one strong in sciences/engineering, other in liberal arts + management)
- Large corporations
- Sister city w/mature economy
- Sector growth
- Plus, rule of law, infrastructure, culture, society embracing mobility, tax policy

For engineering education to be effective, it needs to consider developing the innovative engineer, one who invents new processes and ideas and some even take risks starting new businesses (entrepreneur).

2.4 IMPLEMENT CONTINUOUS ASSESSMENT AND ACCREDITATION TO DRIVE EXCELLENCE

Higher education institutions and engineering programs need to collect of data to be able to understand and interpret the institution/program, make intelligent decisions about current operations, develop plans for the future and improve the efficiency and effectiveness of the system. Data also provides a mean to understand internal operations and the effectiveness with which leaders and others are using their resources. Universities and programs need to engage in serious institutional research in order to provide information which supports planning, policy formation, and decision making. Finally, there's the need to be accountable to society.

There are various definitions to outcomes assessment, but a widely accepted one is: *outcomes assessment is a process to improve the quality of an academic program, student learning, and student success based on real evidence.* It is a continuous process that involves planning, assessing, data analysis, feedback, and making programmatic improvements. Outcomes assessment also involves documentation, stakeholder input and sharing of results. Integrating outcomes assessment and continuous improvement into academic programs have become a major goal of every engineering educational institution (McGourty, 1999). Moreover, with the new ABET accreditation criteria (www.abet.org) established in the US in 2000, the push is for outcomes assessment across the globe.

If education, in general and engineering education in particular, is key foundation for society, all institutions and programs should strive for excellent through continuous quality assessment (internal driver for excellence) and through accreditation (external driver for excellence). The quest for excellence through internal and external drivers begins with strategic planning, which establishes the roadmap that responds to various intertwined contexts with the ultimate outcome of influencing change. In order to make sound, validated decisions based on actual data, planning, executing, assessment and feedback are critical for decision making.

Engineering program accreditation as mentioned above is a widely used external driver of excellence.

> *"Accreditation is a process of external quality review created and used by higher education to scrutinize colleges, universities and programs for quality assurance and improvement." Judith S. Eaton, President, US CHEA*

In many regions around the world that undergo engineering program accreditation either voluntarily or mandated, the process brings the following benefits: assures quality in education, allows access to external (federal) funds, provides a means for ease transfer of courses and programs and lastly and very important to those hiring engineers, accreditation provides employer confidence.

For engineering education to improve, it has to integrate internal and external drivers of excellence through planning, continuous outcomes assessment and accreditation.

2.5 EDUCATE THE FUTURE ENGINEER PROFESSOR

Most reports on engineering education tend to emphasize "what" needs to be changed. "How" the change should be driven and "who" should drive the change have generally not been as fully addressed, both of which largely determine how quickly and how well change occurs and how it is sustained (Morell, 2010). Most fundamentally, many engineering education reports fail to reach the base: absent are guidelines for the engineering professor looking for best practices and roadmaps to become a better educator and professional.

Many may argue that the ideal engineering graduate of today and tomorrow has already been described ad nauseam and that - as a result - millions of dollars have been invested to innovate and reform engineering education. But the fact remains that the engineering education ecosystem has not developed in the way expected and required.

In spite of all these efforts, still the same questions remain unanswered: What is the problem with engineering education, and why has the profile of the engineering professor been ignored in this discussion? Why the continuing problems of recruitment and retention of engineering students with all of the resources devoted to curriculum development? Why the lag, as previously described, between the advancement of science and technology vis-à-vis the evolution of the engineering education model? Why are so many worried that the profession will not be able to serve society and support and sustain economic development as it has in the past?

The answer may very well be, because, there's been little systemic effort to change/educate the 'catalyzer' of engineering education: the engineering professor!

A 2009 survey undertaken by the author and the President of the Student Platform for Engineering Education Development (SPEED) aimed at describing what the profile and general characteristics of the ideal engineering professor (Morell, 2010). Figure 4 describes the major findings of this global, multi-stakeholder survey.

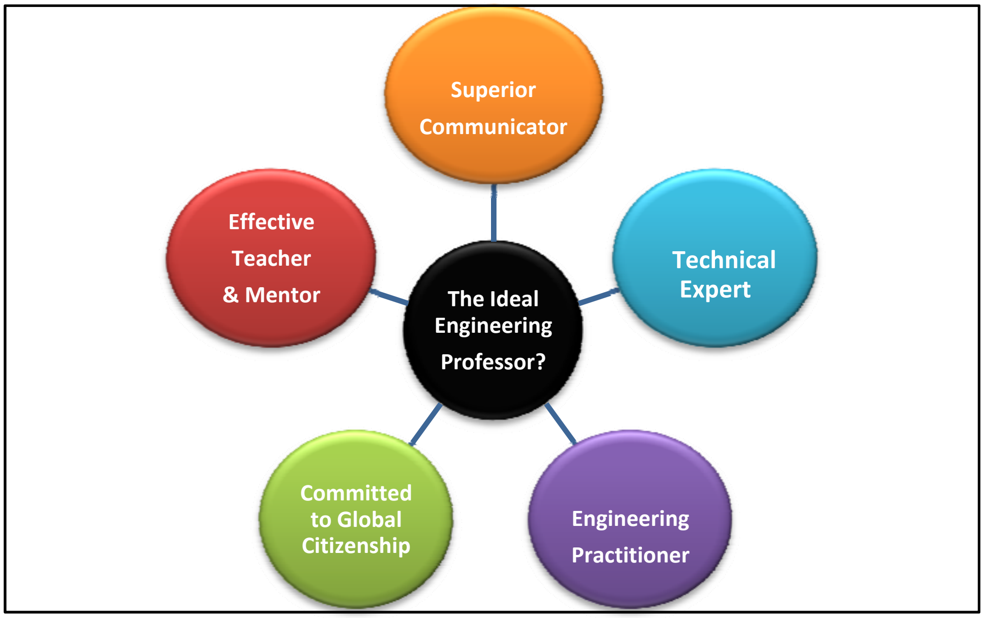

Figure 4: The Ideal Engineering Professor (Morell, 2010)

The engineering professor of today and tomorrow needs to be a blend of the two professions, engineer and educator. He/she must be an individual who:

- Is competent in his/her own discipline, engineering fundamentals and problem solving
- Is current in his/her research, publishes, networks, communicates effectively and keeps up with trends in his/her discipline; and does all of the above with an entrepreneurial spirit.
- Is an effective teacher, knows about learning and outcomes assessment, facilitates learning using learner-centered strategies, keeps up with developments in engineering education, studies and uses the effectively, cares about the students and their learning, enjoys being as a mentor.
- Understands the role that the profession has in society both locally and globally, practices it as part of his/her career development as well as leads, serves and participate in forums to promote policy making and excellence in engineering education and research/innovation.
- Aims at developing the skills and competencies engineers should possess through practice and experience in order to better serve society and be a role model for students.

At Hewlett Packard Laboratories (HP Labs), Open Innovation[1] is a core element to augment and accelerate knowledge creation and tech transfer. Projects underway include joint research with universities worldwide, collaborations with customers and partners and research and internship/postdoc programs co-funded by governments. Engagement with government agencies in the US, UK and selected strategic geographies has helped broaden HP Labs' reach and ability to conduct critical IT research and host a number of interns and postdocs, a unique opportunity for the development of future generations of scientists and engineers to grow the critical skills for future product and service innovation. Programs of this nature lay the foundations for future partnerships with universities and newly qualified researchers, as well as being a vital investment in the future health of the innovation ecosystem.

[1] Henry Chesbrough defines Open Innovation as "the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively. [This paradigm] assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as they look to advance their technology…"

In 2009, HP Labs - with the support of several other corporate research labs – led the creation of a pilot program at the US National Science Foundation (NSF) to allow corporate labs host engineering postdocs. In 2010, the Industrial Research Innovation Post Doc Fellowship Program run by the American Society of Engineering Education (ASEE) provided 40 top US engineering post docs to work with corporate scientists [Morell, 2010]. The program posted 160 research positions by 47 companies (only 40 filled) and over 450 candidates responded. HP Labs hosted five (5) of these postdocs working on cutting-edge research in areas such as next-generation displays, nano-technology and information management with very positive results.

These kinds of opportunities provide future professors to experience engineering and research/innovation for a purpose beyond publishing a paper, obtaining external funds and supervising PhD thesis. They become aware of technology/science frontiers, business constraints and the need for special skills in the workplace (like working in multidisciplinary multi-geography, multi-stakeholder team projects) so innovating engineering curriculum accordingly be a natural for them.

For engineering education to be effective, it must plan to develop and educate the engineering professor, one that is experienced in the profession as well as knowledgeable of the learning process.

3. CONCLUSION

Higher education, in general, is responsible for formally preparing the next generation of 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 developing a new set of skills and competencies. The author lists five things engineering education can do to better respond to society's needs: innovate, reform the engineering curriculum AND the learning experience; focus on learning (not on teaching), foster creativity and innovation across the ecosystem, implement continuous assessment and accreditation to drive excellence and educate the engineering professor of the future. These may seem impossible to accomplish, but not as difficult as the grand challenges the world is facing and will continue to face in the future. There are many good benchmarks and good practices around the world. It takes leadership to plan and allocate the right resources. But change only starts when individuals change first.

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