2. GLOBAL ENGINEER: IMPERATIVES AND IMPLICATIONS

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1. Introduction

Today Engineering Education (EE) is at a critical stage all over the globe and India is no exception. There is an explosive growth in number of technical institutes/universities, and colleges in the country. This is naturally reflected in tremendous growth in number of graduates coming out of these institutes. There is a wide feeling amongst professionals that the employability of such graduates needs to be enhanced. Although basic engineering concepts don't change, the knowledge explosion, the ever-increasing complexity in which engineers work and the changing global economy demand new paradigms to shape professional skill sets and competencies of new engineering graduates. It is envisaged that engineers will be required to play an important role in creatively solving global and complex challenges related to energy, health care and environment. These engineers, need to work with an understanding of multiple disciplines in collaborative teams that are culturally and philosophically diverse; cultivate complex communication and social skills. The growing pace of innovation, both in terms of products and emerging business models fuelled by net economy, is also likely to make the job of an engineer quite challenging. Overall, engineers must learn to work with ambiguity/uncertainty, diversity of disciplines and with an open mind regarding their own skills and abilities.

2. Imperatives

it is also helpful to identify the drivers for increasing the global dimension across higher technical education, in general. These can be summarized in terms of the following:

- Strategies and initiatives on sustainable development including the general global focus on reducing carbon footprint and overall thrust on using green technologies. Such efforts require a global outlook, integrating both developed and developing economies to evolve unified strategies and solutions thereof.

- Universalization of Engineering Education and thrust on international accreditation (by agencies such as ABET) . This is also spurred by India being a signatory to Washington accord. It is also to be noted that India has recently hosted first World Summit on Accreditation(WOSA-2012) in March 2012 which generated lot of interest amongst the international community to view India as a preferred destination.

- International strategies of institutes/ universities (example: some of the private universities such as VIT Vellore, Symbiosis Pune, Manipal Institute of Technology, Manipal, Amity University etc.) based around securing more international students,. At a later stage, this will also motivate export of courses and expertise across the globe

- A wider appreciation of the importance of

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internationalization and promoting concept of graduates, as global citizens.

- Impact of globalization and the need to upskill our technical workforce, so that it is more globally competitive.

The above drivers are complimented by a variety of other developments occurring on a global scale. The following factors are responsible for making the world a highly interconnected and close society (or in Friedman's word: a flat world!):

a) Developments in Information Technology(IT) such as communications, (such as mobile, internet, and web enabled technologies)

b) Tremendous impact due to social media(such as Facebook, LinkedIn, Orkut, etc.)

c) Tremendous employment opportunities due to software/IT enabled services and growth of BPO etc.

d) Liberalisation of economy(especially in countries such as India, and a few south Asian countries)

e) Globalisation of issues (Today, it is very difficult to restrict/insulate /isolate one country from the other)

The fact that, we live in a highly-connected, knowledge-based world, reinforces the need for new sets of engineering competencies and professional skills to take on the Grand Challenges in a sustainable manner. Engineering Education should, therefore, not merely focus on local challenges, but should attend to regional and global opportunities. Workplace demands that future engineers be technically qualified, flexible, problem solvers, creative and dynamic thinkers.

It must be noted that:

- Engineers see themselves as an integral part of a global society.
- They are also embedded in their local environment and the slogan "think global, act local" is part of their philosophy of life.
- They have the will – and ability – and skills to work across all political, cultural, and ethnic boundaries

As technology develops, especially in the fields of communication and IT, it links even more closely every part of our rapidly shrinking world. We are experiencing increasing global interdependence, with engineers expected to exercise leadership in confronting the world's most dynamic and complex challenges. Engineers are uniquely positioned to offer solutions because of their creative problem-solving abilities and systems thinking.

It is clear that a traditional engineering curriculum that is heavy in technical content will not be sufficient to prepare engineers for the global workplace. Forums such as Global Mobility forum expect universalization of engineering education and consequently, seamless movement of engineers from one country to another without any boundaries. It is essential that such mobility is not possible unless engineering education is replete with a variety of skills and competencies. It is expected that the engineers practice real and virtual mobility on a global scale

The following characteristics of a global engineer (GE) are to be noted:

The "Global Engineer "has/shows evidence of:

- Providing leadership and vision
- Focus on business / clients
- Focus on international opportunities
- Focus on required roles / results
- Commitment to ethical and social responsibilities
- Team-working: multidisciplinary / cultural

- Management of projects / events, Management / motivation of people
- Management of knowledge / IT and Management of self / time

3. Competencies Expected

This calls for a need for an increase in engineers' core capacities that will enable them to work more effectively and effortlessly on global issues. The world needs "global engineers." In addition, to the typical attributes expected, the global engineer must also demonstrate additional characteristics and qualifications.

Some of the key attributes of a GE are:

i. Excellent communication skills and understanding of different cultures and languages;

ii. Orientation for multidisciplinary / interdisciplinary teamwork;

iii. A well-developed sense of social responsibility and ethics, with due consideration in his/her personal and professional activities;

iv. Entrepreneurial attitude and risk taking attitude; and

v. An ability to deal with complexity and systems thinking.

Table 1 presents a summary of the global dimension attached with the engineering curriculum.

The above table clearly highlights the role of a multi-disciplinary engineering curriculum, coupled with soft skills in understanding the problems and challenges of a finite resource world, in a pluralistic society. This also calls for having a very strong humanities orientation in our curriculum. The above orientation calls for:

a) Imparting strong technical skills to take care of changing technology landscape in every discipline

b) Inculcating strong behavioral skills so that engineering solutions are implemented with a strong focus on unconventional problem solving aptitude

c) Inclusive and exclusive education, taking care of diversity as well as specialized inputs, required to solve complex problems

4. Implications

The agenda of imparting global skills to engineering graduates has several implications. These are highlighted below:

4.1 Systems perspective

The nature of engineering is changing. As can be seen from the global trend, engineering firms are becoming multi-disciplinary and global in their reach. Traditional boundaries between disciplines in science (chemistry, biology and physics) and disciplines within engineering (civil, mechanical, electrical, etc.) are breaking down.

Systems engineering and whole life cycle

Ability to take a broader perspective - application of curriculum across countries
An appreciation of what we do in developing countries impact upon ourselves and the globe at large
Understanding our culture doesn't have all the answers and there is more than one perspective and approach
Understanding the local context of development
coping with uncertainty and continuously challeging stereotypes
Recognition of finite resources in the world and the impact of globalization on rapid depletion of these resources
Mitigating and adapting to climate change
Potential role of different technologies and a view that technology may not be "Value Neutral"

Table 1 : What is the meaning of "Global dimension?
(Source: Based on responses of academicians from UK Stakeholders Meet, 2007)

based analysis, is increasingly common, especially in complex systems. Holistic thinking not only requires understanding complexities within engineering systems, but also the relationship between engineering disciplines and their connections with sciences.

While engineers have operated historically in silos, often disengaged and disinterested in challenges that are not completely within their field, there is an increasing need for them to work in more multidisciplinary teams. This includes not only engineers in other sub-disciplines, but also people outside of engineering (e.g. policy-makers, medical doctors, economists, environmental activists and civil society). This justifies the need for a systems perspective.

4.2 Innovation perspective

The global agenda can not be visualized unless one give due importance to innovations in engineering curriculum. The GE must be comfortable in handing innovations. The necessary eco-system for innovations must be developed and nurtured by the technical institutes. These innovations can be both incremental as well as discontinuous. This calls for active interaction between academia and industry.

4.3 Entrepreneurial perspective

The global orientation calls for leveraging entrepreneurial capabilities of the GE. The GE is expected to be comfortable in handling risk and with a mind set of enterprise development and the spirit of entrepreneurship. Academic institutes need to incubate business ideas which will help GE to understand and appreciate the role of constantly changing business models and act accordingly.

4.4 Multi-agency perspective

Having understood the need and implications for "Global Engineer", one can appreciate a multi-agency perspective. This perspective visualizes the active role that is to be played by these agencies in a coordinated and cooperative manner.

a) Role of Higher Technical Institutes (HTI)

1. All HTIs engaged in engineering education to undertake a review of existing courses to consider the extent to which the global dimension is adequately reflected.
2. All HTIs engaged in running courses that include sustainable development and international development, to consider ways in which these agendas can be brought more closely together
3. HTIs to consider the role of active partnerships with Industry/Business and Government in moving forward the global dimension within design, development, review and delivery of engineering curriculum
4. HTIs to develop international partnerships with engineering departments, elsewhere in the world, with a view to furthering cultural understanding and respecting different views and perspectives on global issues and sustainability.
5. to develop a strong knowledge network amongst themselves wherein resources, faculty and knowledge/skills are shared, nurtured and developed.

b) Role of Government

1. MHRD and Regulatory bodies such as AICTE/ UGC to consider developing joint policies and initiatives for incorporating the global dimension within higher education including providing additional financial/infrastructural support to HTIs agenda.
2. Providing incentives for implementing this agenda.
3. Enabling this to prepare the faculty for implementing such agenda.

c) Professional Bodies

1. Professional bodies (such as NAE, Nasscom, Ficci, CII) to consider ways in which the concept of the 'global engineer' can be promoted within HTEs.

2. Professional bodies to identify ways in which the global dimension can enrich initiatives in areas such as engineering ethics, sustainable development, entrepreneurship and professional/soft skills.

3. Professional and research bodies (such as DST, CSIR, ICSSR) to support further research on the impact and value of the 'global engineer' concept in the contribution of engineering to positive world change and meeting the skills needs of the workforce.

d) Employers

1. Engineering employers to promote the concept of the 'global engineer' to their senior managers and staff responsible for human resources.

2. Engineering employers to identify to HTI's and professional bodies, the specific global skills they seek within engineering graduates, particularly with reference to poverty reduction and sustainable development.

3. Engineering employers to review the ways in which their staff can acquire global skills through professional development, Lifelong learning opportunities, sabbatical to academic institutes, mentoring and partnerships with NGOs/ universities and how this links to reforms with engineering higher education.

e) NGOs

1. Volunteering organizations to consider how they can work more closely with HTEs and support the global learning and citizenship within their programmes.

2. Development NGOs to engage with HTIs on the relevance of international development to Engineering Education.

Table 2 highlights the paradigm shift that is expected due to global orientation. It is to be noted that this paradigm shift has implications for various agencies and stakeholders.

5. Concluding remarks

In a nutshell, a typical global engineer (GE) is an engineer (according to Chan and Fishbein, 2009) who:

- understands the broad, holistic nature of engineering work as well as the business and social implications;
- possesses expertise in a specific technical field,(such as Civil Engineering, Mechanical Engineering) but is comfortable in many engineering disciplines and able to work in an interdisciplinary way;
- is a complex problem solver and is innovative;
- can easily adapt and adopt to new situations, deal with complexity and uncertainty and is skilled at systems thinking;
- is able to collaborate on a global basis, including knowledge, skills and/or understanding of people, culture and language;
- is able to communicate effectively both orally and in writing in English, and is able to communicate across language and cultural differences;
- has an understanding of sustainability issues and the ability to factor environmental impact and energy-use implications including carbon footprint into all aspects of his/her work;
- is up to date on current global issues (both from developing and developed economies) and emerging technology trends and is constantly expanding his/her skills to be able to respond to these issues appropriately;
- has a sense of social responsibility and ethics, with due consideration in his/her personal and professional activities for the world and society; and

Sn	Moving away from	Moving towards	Significant Role to be played by
1	Fixed content and skill set to conform to a predetermined idea of present and future needs	Concepts and strategies to address complexity, difference and uncertainty of a continuously evolving world enabled by technology	HTIs, Employers
2	Absorb ing information, reproducing the same and accepting and adapting to existing structures and models of thinking, knowing and application of the knowledge	Assessing, interrogating and connecting information, generating knowledge, living with difference and conflict and shifting positions and perspectives according to contexts and developing ability to continuously challenge the status quo	Students, Employees, Employers
3	Structured, ordered and predictable, comprehensible as a world view	Complex and changing, uncertain, multifaceted and interconnected world view	HTIs, Employers, Employees, Professional Bodies
4	Focus on fixed curriculum based learning	Focus on Life long learning concepts	HTIs, Professional Bodies
5	Fixed and Rigid mindset	Flexible and Adaptable mindset	Students, Employees
6	Minimal or limited role of Humanities orientation	Greater role for Humanities	this

Table 2: Moving away and Moving towards from the perspective of "Global Engineer"
(Source: Based on Bourn D, 2008. "The Global Engineer Incorporating global skills within UK Higher Education of Engineers", Development of Education Research Centre, UK

- is entrepreneurial and is prepared to work with a varying level of resources and in various types of organizations in many different roles.

Given the complex, social and technological challenges, it is imperative for Engineering Education to develop global engineers. These engineers would require not only hard skills but soft skills which will make them comfortable in handling challenges of knowledge driven economy in an extremely interconnected world.

Engineering Educators must take a hard and impassionate look to consolidate, intensify and reformulate engineering curriculum, as a whole, to make "Global Engineer" possible, with a deep understanding of the social, cultural, political and physical environment.

Engineering Education must recognize, promote, and reward the global mobility of students and professors. This mobility includes courses, research and outreach activities.

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