The Global Engineer: A new Paradigm for 21st Century Practice

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Outline

- Global Engineering: What, Why, How ?

- Objectives of new engineering curricula-
  Undergraduate & Postgraduate Studies

- New competencies required of leading engineers

- Principal criteria to succeed in global marketplace

- Closing Remarks

Challenges for Future Engineers

- Continuously growing complexity, uncertainty, inter-disciplinary, multi-scale systems from nano to mega scales, etc.
- Explosive growth in S&T knowledge
- New technical and socio-technological challenges
  - **Infrastructure, urbanization**
  - **Aging population, demographic changes**
  - **Security issues due to potential shortage of energy, water, food, etc.**
  - **Sustainability, etc.**

Global Engineering - Some of the following criteria apply to all engineering programs

- Globalization and the proverbial "flattening" of the world ensures global scale competition from both developed and emerging economies
- Innovation in knowledge-driven economy is no longer a monopoly of a few nations
- Creating national wealth requires innovative transformation of knowledge into cost-effective and globally competitive new products, processes and even services
- Productivity of engineers in high cost economies must be commensurate with the cost of engineering- greater productivity is required

Global Engineering – Some Criteria

- Ability to translate inventions/creativity into innovations requires special skills and mindset

- World class engineers need ability to work in intercultural , multi-lingual, multi-national team settings needing soft skills

- Self-learning, life-long learning, ability to synthesize information from diverse sources in addition to ability to analyze problems critically are required traits

Global Engineering – Some Criteria (cont'd)

- Develop soft skills: oral/written communication, ability to negotiate, have knowledge of IP, law, ethics and economics/finance

- Able to work in teams and work collaboratively with international teams if necessary

- Able to form networks and be able to simultaneously collaborate and compete

Note:

"Global" includes wider geographic as well as wider coverage of subjects in curriculum

Global Engineering – Some Criteria (cont'd)

- Some propose greater diversity, inclusion of the arts in engineering and engineering in liberal arts curricula so engineers can effectively participate in politics, economics and in policy making

- Research-based innovation and continuous enhancement of engineering education – will stimulate innovation

Engineering of tomorrow needs following features in education

- Shift away from repetitive, routine aspects which can be computerized or do not need high caliber effort

- As large corporations may be challenged by entrepreneurial small & medium size companies, engineers need to resourceful, up-to-date and self-starters

- Self-learning and life-long learning are essential traits of future engineers as half-life of engineering education is being shortened continuously – now estimated between 3-7 years!

Bordogna, 1993 lists following possible careers for various branches of engineers:

- Sustainable development; energy/materials efficiency
- Lifecycle assessment/ reuse/recycle
- Micro-, Nano, micro-electromechanical systems
- Mega scale systems
- Smart systems
- Multi-media
- Living systems
- Innovation management
- Enterprise transformation

Reference: Bordogna, J.J, Engg. Education, January 1993

Competencies needed to compete in globalized world

- Think global , act local!
- Appreciate and respect national , cultural and linguistic differences
- Develop ability to integrate knowledge across a broad range of field
- Ability to work at interface of disciplines
- Have a broader vision –better than 20:20!
- Able to take risk, push boundaries and innovate
- Use both sides of the brain- combine arts and sciences where possible
- Be nimble, mobile, resourceful with passion and initiative.

In short the future engineer needs to be a polymath- knowledgeable in several fields!

Bordogna (2003) lists following skill sets needed by engineers today

- Analysis
- System integration (synthesis)
- Problem formulation/problem-solving open-ended problems
- Design-including selection of specifications and final cost-effectiveness
- Manufacture products to specs
- Manage complexity under uncertainty
- Team spirit, leadership qualities
- Ability to work with multicultural, multilingual groups
- Entrepreneurship
- Knowledge of professional ethics, applicable law etc

Above set excludes basic sciences/ humanities/ disciplinary engineering subjects etc which are essential to practice engineering

Engineering Education: Teaching & Learning

- Need to add new subjects and enhance both breadth and depth, technological advances are being used

- Note that ultra-fast transmission of information does not necessarily convert into knowledge in the students' mind!

- Transfer of knowledge from teacher to student is a typical rate process (as in heat and mass transfer)- the net flux of knowledge absorbed by the receiver depends on resistances to teaching and learning as well as an interfacial resistance

Teaching & Learning (cont'd)

- Excellent teaching reduces "teaching-side resistance"; "learning side resistance depends to a great extent on the ability, motivation and passion of the receiver to absorb the knowledge directed at him/her.

- Additionally ,interfacial resistance can appear due to nature of the subject matter; inherent conceptual complexity of the subject etc.

- All three resistances to knowledge transfer need to be minimized for effective learning by students.

Teaching & Learning (cont'd)

- Discovery-based, hands-on learning can work for many students as it is active rather than passive learning

- Problem –based learning, Research Project-based learning techniques can stimulate independent critical thinking skills as well as in enhancing motivation

- Current "plug and Play generation of students can effectively multi-task and have skill to switch between different tasks easily.

- Children born in the digital age think differently and may learn differently as well! Jury still out?

New paradigm?

- Today's students are active learners who follow a nonlinear path to learn. Structured linear path typically followed in teaching may not interest them

- Faculty need not be information providers/presenters but rather mentors and advisors or facilitators

- Faculty should encourage peer-to-peer learning

- Conventional exams test ability to reproduce rather than produce or absorb knowledge; this can demotivate learners

New paradigm? (cont'd)

- Faculty need to nurture students; inspire, motivate and coach students
- Multidisciplinary design ; formation of multicultural teams to do projects (when possible) gives added experience
- Working with industry, having faculty from industry or faculty with significant industry experience or connections can provide valuable mentoring to students
- Multi-disciplinary design/research projects with international teams would give additional global exposure

Limitations in exploring new avenues - possible options and outcomes

- Only possibility is to add extra time- maybe a year- to fill the gap

- Academia ,industry and government and the student need to pick up the tab- each has different requirements

- Making Master's degree the first professional degree is one idea

- Industry may not pay premium for a better-educated engineer unless they can utilize him/her to benefit from the additional skills set

Limitations in exploring new avenues -2

- Student may be unwilling to bear the extra opportunity cost- loss of present income for higher future payback

- Cost to state /academia will increase leading to higher fees

- As half-life of engineering curricula is in the order of 5-7 years, lifelong learning capability is the workable solution

- Supply and demand equation works in the free market; engineers' numbers are not controlled unlike those of doctors, dentists or lawyers; this diminishes incentives for talented students who seek greener grass in other fields

Limitations in exploring new avenues -3

- Reduced interest in hard subjects like STEM coupled with lower returns on investment in education in these fields makes it harder to enhance engineering education levels to meet future needs

- Nations with resources and willpower to do so will become wealthier and win international competition for markets

- Engineering R&D is needed for innovation and enhancement of productivity- well trained engineers are needed for this intellectual, challenging activity

Summing up:

All avenues need to be explored to enhance engineering education and make it relevant to needs of the 21st Century. Combining engineering with liberal arts is pedagogically attractive but not realistic at this point in time in most parts of the world.

Closing Remarks

- **Engineering education – content and how it is delivered need major upgrade to meet new learning environment and student body**
- **Global engineers need a broader set of soft skills to handle multi-disciplinary, multicultural and multinational projects of much larger scale**
- **Focus needed on creativity, critical thinking, innovation along with concern over life cycle costs, sustainability and professional ethics**

Closing Remarks 2

- **In academia major focus needs to shift from teaching to learning**
- **Professors need to be guides, coaches, mentors to students who are adept at seeking right information from the internet. Objective should be to be able to convert information/data into usable knowledge**
- **Important to make engineering an attractive profession which requires close collaboration between industry, business, government and academia**

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Q & A