WORLD CLASS ENGINEERING EDUCATION TO MAKE INDIAN ENGINEERING WORLD CLASS

Prof O R S Rao[1]

ABSTRACT

World Class Engineering refers to adherence to the best Global Quality Standards in every phase of Engineering from R&D till manufacturing, testing and commisioning. Engineering profession in the next two decades will undergo dramatic changes, driven by not only technological developments but also societal transformation. Besides increased globalization , more acute concern for environment for sustainable development will characterize changes and challenges for future engineers in their roles. As industry increasingly looks at Corporate Social Responsibility not just as mandatory but as key to success, future engineers should change their mind sets and incorporate sustainability and corporate social responsibility as key parameters in their day-to-day working as well as decision making framework. As roles of future engineers expect different sets of competencies from the graduating engineers, it is the responsibility of the educational institutions to reinvent themselves and brace themselves for a paradigm shift in the way, students are groomed to match the changed expectations. Consequently , the way the components of education namely , knowledge, skills and attitudes & values , are to be imparted has to be different. Contents as well as pedagogy will need to be changed accordingly. This tectonic shift will pose challenges to all the stake holders - educational institutions, industry, government , teachers and students . All of them need to work together as partners to address the challenges. It also calls for change in mindsets of all stake holders so that the transition is smooth and successful. Concerted and synergistic efforts from all of them will help to make Indian Engineering Education world class so that Indian Engineering becomes truly World Class , which will enable the dream of seeing "Made in India" products all over the world, a reality. fatigue resistance as the honeycomb panel facings are continuously bonded to the core and therefore no stress concentration is seen.

Keywords: Engineering Profession, Future Engineers, Problem Solving, Components of Education, Role of engineering education, Digital Age, Teaching-Learning, Blended Learning, Life long learning, MOOC, Sustainability, Green Technologies, World Class Engineering.

1.0 Making Indian Engineering World Class

World Class Engineering refers to adherence to the best Global Quality Standards in every phase of Engineering – starting from product innovation, design, analysis , manufacturing ,testing , delivery , commissioning and maintenance of products , wherever they are made. It is in line with the recent clarion call of our Honorable Prime Minster Sri Narendra

1. Vice Chancellor, The ICFAI University, Jharkhand

Modi to produce "Zero defect" products in India and dream of seeing "Made in India" products all over the world. It is possible only when we understand how the engineering all over the world is moving forward , crystal gaze the Engineers of the Future and what it takes to produce them in India. Unless our Engineering Education is world class, our engineering can not be World Class.

2.0 Engineering Profession of the Future

We need to ask ourselves the basic questions about future engineers - who they will be, what they will do, where they will operate , why they will do certain things , and what they imply for Engineering Education. We should also anticipate the environment in which they will operate and the challenges , they will be facing.

The changes and challenges faced by future engineers in the next decade may be classified into following categories:

1.Technological Developments: In most part of the 20th century, developments in Technology were essentially in well defined disciplines like Civil, Mechanical, Electrical, Chemical etc. However, last 25- 30 years have seen growth in multiple directions. Besides specializations under each discipline like (Electronics, Telecom , VLSI, Embedded systems etc),specific application domains like Automobile, Aeronautical ,Oil and Gas started developing, A more important development has been the emergence of multi-disciplinary and interdisciplinary areas like Mechatronics, Auto Electronics, Bio-medical , Robotics etc. Convergence of IT, Internet, Telecom and Electronics and its impact on all disciplines is mind boggling, with emergence of areas like automotive telematics ,mobile info-tainment , Intelligent Power Grids etc. For instance, autonomous self driving car was developed by Google (and not any of the auto majors). It is Google and Apple that are setting standards for Embedded Infotainment systems in a car. In this environment, any engineer can not afford to live in his "own world" but should be open to learn other disciplines and work together with them to evolve solutions to day-to-day problems.

Globalisation : With increased globalization, companies compete globally for every thing ranging from products, markets, resources etc. As Indian companies set up and scale up global operations, engineers are called upon to work anywhere in the world . In order to be successful in these markets, engineers need to be culturally adaptive.

3. Concern for Environment and Sustainability : for the past over 150 years, most of the remarkable Engineering / technological achievements of were based on the paradigm of controlling Nature rather than co-operate with it. Ironically, the same successes like fossil fuels, automobiles, plastics etc have endangered human life. For the last few years, there has been more awareness and concerns among people and governments on conservation of Nature and sustainability of growth. So much so, some companies started focusing on Triple Bottom Line (Profit, People and Planet) objectives that are essential for sustainability . In the next few decades, engineers must change their mind sets to contribute to building a

more sustainable world. In this context, it will be mandatory for the Engineers to adopt Green Technologies for design of products addressing industry/social problems.

It is these developments that have been driving the recent fast pace of R&D in areas like Electrical Automotives. China is planning to have at least 2 million Electrical Vehicles on its roads by 2020 (which will be the largest EVs in any country) . No wonder, Samsung is setting up R&D labs in China to produce cost effective batteries for EVs and a lot of R&D going on for wireless charging of EVs. During Oct 2014, Chen Xiaodong and his colleagues at the Nanyang Technology University in Singapore, announced the development of a battery that is a substantial advance on existing batteries. It will charge 70% of its capacity in just two minutes and it could last as long as two decades. Both the properties are invaluable for electric cars, but are also useful for the next generation of devices too.

Renewable Energy and Solar energy , in particular, could be the top source of electricity by 2050, due to fast declining costs of the solar equipment like Photovoltaic Panels and Systems. Batteries will store the solar energy at night and allow us to use it when the sun does not shine. For the first time after the industrial revolution, we will have a viable alternative to coal for electricity and alternative to oil for transport. As per the report from the International Energy Agency (IEA), dated 29th Sep 2014,Solar Energy could scale up from less than 1 % global capacity today to 27% (16% from PV systems and 11% through Solar Thermal Energy (STE) . As per the report, Solar energy expansion will be led by China, followed by the United States, Africa, India and the Middle East.

4.Corporate Social Responsibility: Industry converts natural resources into socially or commercially useful products and services using human resources. In this process ,it is likely that day-to-day lives of people are adversely affected . In some cases, people are displaced in projects like exploration of natural resources (like Coal, Iron ore, gas etc) or setting up infrastructure projects (like power) . Industry has to take the responsibility to address the consequent social problems. Last decade has seen increased awareness and sensitivity to such issues . Next decade will see Corporate Social Responsibility not just mandatory but a key parameter for success of organisations and engineers , as professionals.

5.Abrupt changes: Current century is characterized by sudden and dramatic changes in economic and social environment due to factors like terrorism, European Economic Crisis, Social upheaval in Middle East etc. The world will witness more such cataclysmic changes , in the years to come, The future engineers need to acquire skills to anticipate such changes and more importantly, adapt themselves and mange them successfully.

3.0 Role of Engineering Education in grooming Engineering Professionals for future:

As the environment in which engineers will operate in future will be different , role expectations from them and challenges faced by them will also be different from what they

were in the last century. Roles performed by fresh engineering graduates in the last century were mostly routine and technical in nature, pertaining primarily to a single discipline of Engineering studied by them. Engineering students acquired the requisite knowledge through class room lectures and skills through working on experiments in laboratories and workshops . However, role expectations from fresh engineering graduates in future will be more complex - interdisciplinary in nature and must have skills to use latest technology tools and interact more intensely with society . Accordingly, components of education (Knowledge, Skills and Attitude) that need to be imparted will be different ,though certain fundamentals remain unchanged. Likewise , the way learning will take place, in terms of Teaching-Learning-Assessment processes also will be different.

2.1 What to teach-learn?

Components of education that need to be taught /learnt can be classified into Knowledge, Skills and Attitudes and Values .

2.1.1 Knowledge: Amount of new knowledge created has been increasing exponentially every passing day, in every discipline of Engineering / Technology . Besides it is easily accessible to any one through Google. At the same time, knowledge requirements for different industries and different roles vary widely. In real life, problems will not surface with the tag of specific disciplines. There is no way that any Engineering educational program (under graduate or post graduate) can cover or impart all knowledge required ,as a part of its curriculum.

A pragmatic way to address the issue could be : to teach core fundamentals of requisite sciences and engineering ,besides social sciences and students are enabled and encouraged to learn new knowledge ,on their own, as and when needed . Every student must be made conscious of the imperative for Life-Long Learning and ways and means of self study for continuous learning. Encouraging students to register for Massively Open Online Courses (MOOC) like edX, Coursera, Khan Academy , NPTEL etc to supplement class room learning will initiate them to continue similar means for self –learning , after they graduate.

Besides, the students should be equipped to diagnose real-life problems , identify the type of knowledge needed and more importantly, how to integrate the relevant “pockets of knowledge learnt” to solve the problem on hand.

2.1.2 Skills: While during the last century, Engineering Education focused primarily on imparting technical skills to the students, in future, there is need to focus more on cognitive and behavioural skills in areas like critical thinking, problem solving, self-assessment, integrative thinking, self-learning, inter-personal, communication and change management. Industry is increasingly looking for Higher Order Thinking (HOT) skills like Analysing, Evaluating and Creating.

Besides looking at the requirements of the industry, with a view to make the graduating students employable, educational institutions in future , must also impart requisite skills to

make the students self-employable , either as entrepreneurs or as freelance independent professionals. Essential skills in this regard include Entrepreneurship, Finance and Marketing.

2.1.3 Attitudes , Values and Ethics : Failure of the education system to systematically address the issues of attitudes and ethics has already created adverse impact on the society . The World as well as India have witnessed how the greed of a few individuals , in whatever walk of life- business men, professional managers, entrepreneurs, bureaucrats, academicians or politicians- caused immense hardship to the entire society by way of collapse of companies, loss of jobs ,turbulence in financial markets or slow down of economies.

In view of this, it is becoming increasingly critical for Educational Institutions to put in concerted efforts to shape the character of the students , by inculcating positive attitude, with good personal values so that the graduating students can become not only competent professionals but also good human beings and lead a happy life and more importantly allow others to lead a happy life . Students must be made conscious of social, moral and ethical considerations in their day-to-day working as well as in decision making. It is too simplistic to assume that a course on humanities in the curriculum is adequate to bring about such an attitudinal change . It needs systematic inputs , followed by practice , accompanied by patient counseling so that the principles are ingrained in the minds of the students and become part and parcel of the personality of the students. There is no other better way of doing this than by teachers being the Role Models of personal values and ethics.

2.2 Teaching-Learning-assessment processes

Pedagogy to be adopted needs to be different in the context of the changed environment , in which the students are groomed . Students born after 1995 were brought up in a digital age , wherein technology has been an integral part of their day-to-day life . Information and Communication Technologies (ICT) can help in improving the effectiveness of Teaching-Learning processes. Audio-Visual technologies can help in enhancing retention levels whereas online learning can facilitate convenience enabling a learner to study when he wants or where he wants. Virtual Class rooms can help in simulating real class room environment facilitating interactivity among the student-teacher-other students. Virtual Laboratories can facilitate conduct of experiments that may not be feasible to do physically because of reasons of cost or hazard.

Blended Learning, wherein technology and traditional teaching methods can be judiciously combined , can get the best of both worlds. Flipped Classrooms (also called Inverted Classrooms) approach can be used to make students learn the concepts at home , using technology and practice the same in the class room, under the guidance of the teacher.

However, no amount of technology , however sophisticated, can substitute a teacher, though the role of a teacher will undergo a dramatic change , in future. It will be the teacher that has decide on the most appropriate method for teaching, depending

on the subject and the profile of the learners and act as a facilitator and a coach , by guiding and monitoring their learning.

While imparting knowledge may be relatively easier, it will be more difficult to impart skills, more so , in the case of soft skills and cultivation of attitudes. Teacher has to identify clearly the skills to be imparted and communicate the importance of the same to the students convincingly. Besides, he/she has to design appropriate action learning activities to get them practiced by the students . Grading system to evaluate the performance of students for such activities should be more on the process , rather than on out comes . Assessment of the students should be continuous and students should be given feedback at every stage and are counseled for better performance.

4.0 Challenges:

Future engineering education will be able to meet the aspirations of the new age students , only if all the stake holders put in concerted efforts in a synergistic manner . However , each of the stake holders will face challenges , which need to be addressed.

3.1 Educational Institutions :

Educational Institutions have to invest adequate resources in terms of money and quality human resources to ensure a paradigm shift from current system to the a new system. Next few years will also see a shake out in Engineering Education, which has scaled up capacity very quickly in the last decade ,without taking care of quality. The shake out has already started in 2013 , which will accentuate in the next five years . Only such of the institutions with commitment to quality education ,without looking for quick financial returns will survive. It is upto the educational institutions to interact more actively with industry and society and identify the changed expectations from the students. They should bench mark themselves with the best-in-class institutions globally , get accredited by international agencies and can target global rankings.

There is need for the Institutions to seek partnerships with industry so that competency of the graduating engineers is in line with the expectations of the industry. Involvement of the industry should be broad based and should start from curriculum development , guest lectures , hands-on projects etc.

3.2 Industry :

Industry needs competent engineering manpower not only to produce quality products and services but also for its growth. Today the industry is pending a lot of money to recruit and train the graduating students so that they can be deployed productively. So, it is in the interests of the industry to work hand-in- hand with the educational institutions , for mutual benefit. Industry , over a period of time, can look forward to centres of competence in education to help solving their technical problems.

3.3 Government policies and regulation :

Government and regulators will face the challenge of increasing Gross Enrollment Ratio (GER) without compromising on quality. It will also be challenging to set standards of quality , in an environment , where there is

wide disparity in quality of education in institutions across the country. Regulatory framework , in future, should be more facilitative than restrictive. It should encourage innovation rather than control centric . Government will also face the dilemma of how much autonomy to be given to institutions versus how to ensure maintenance of minimum standards . While there are benefits in welcoming foreign institutions into India in engineering education, government policies have to ensure that they should help in improving the quality of education . Success in future engineering education will depend on how government will be able to strike a fine balance among the key legs of the tripod - Expansion, Equity and Excellence, while formulating and implementing its policies.

3.4 Role of Teachers

Teacher is the fulcrum , on whom quality of future education lies, particularly in highly knowledge centric area like engineering education. A teacher has to equip himself well in the same three components of education (knowledge, skills and attitude) so that he can be more effective in the changed environment. Besides acquiring higher qualifications, he has to keep himself abreast of the latest developments in his field by attending seminars and short term programs. Pursuing online MOOC courses can be an excellent opportunity not only to enhance his knowledge but also get insights into more effective pedagogy. In order to leverage technology for effective teaching-learning, a teacher must know about the range of technology tools available and also acquire skills to blend them with traditional teaching methods. Unless the teacher is perceived as a role model by the students, in his values and ethics, he can not inculcate the same in the students.

3.5 Students

Ultimately, it is upto the students to take the ownership for their own careers (and Life ,as a whole) and make the best of the opportunities to learn. They should understand that learning does not stop with their formal education and have to strive for life long learning. They should be conscious that skills and attitude are more important than merely getting good grades / marks in the examination. They should update themselves on the fast changing industry environment and the consequent changes in skill requirements and acquire the same . They should be realistic with regard to their career expectations and must be adaptable to seize the career opportunities, as they beckon. Next few years will present exciting opportunities for self employment, which need a change in mindset of the students.

4,0 Conclusion

Next few decades will see major changes in the environment ,driven by not only technological developments but also changing society . Future Engineering Education must reinvent itself and re-engineer itself to make it relevant for the industry and society, at large. It needs concerted efforts from all the stake holders to effect the transition smoothly and

successfully and build a strong edifice for the Future of Engineering Education so that Indian Engineering can be made truly world class and realise the dream of seeing " Made in India" products all over the world.

Bibliography:

1.Armanado Rugarcia et al , "The future of Engineering Education – a Vision for a new century" , Chemical Engineering Education, 34(1), 16-25(2000)

2.Charles M. Vest, "Educating Engineers for 2020 and beyond" , The Bridge, Volume 36, Number 2 - Summer 2006

3.Donald Woods et al , "The future of Engineering Education – Developing critical skills" , Chemical Engineering Education , 34(2), 108-117(2000)

4.Prof ORS Rao, " Engineering the future of Engineering Education in India" , Journal of Engineering Education, Oct 2013 (PP 8-12) ,

5.http://www.iea.org/newsroomandevents/pressreleases/2014/september/how-solar-energy-could-be-the-largest-source-of-electricity-by-mid-century.html

6. Hari Pulakkat , "Can batteries have a bigger place in our energy future?", Economic Times, Oct 17,2014