Engineering Education: Challenges, Threats and Opportunities

Dr. P. Venugopal Reddy,
Director,
Vidya Jyothi Institute of Technology,
Aziz Nagar gate, Hyderabad- 500075

Abstract:

In this article, an attempt has been made to discuss the future trends in engineering education along with many related challenges, threats and opportunities. The objective of the presentation is to improve engineering education by increasing the awareness among engineering educators and other stakeholder's so as to discus and debate in relevant fora and to arrive at a consensus on these issues. The views expressed in this paper are based on the general perception of the engineering educators in this country expressed on different occasions. The author of the paper based on his experience both at the University and at an engineering college level as an educator, administrator and practitioner made an attempt to compile and comprehend the views, ideas, observations and experiences of various people connected to the subject.

Keywords: Engineering, education, challenges, opportunities, trends, future

1.0. Introduction : -

We live in a time of great change, an increasingly global society, driven by the exponential growth of new knowledge and knitted together by rapidly evolving information and communication technologies. It is a time of challenge as an ever-increasing human population threatens global sustainability. The global knowledge-driven economy places a new premium on technological workforce skills through out-sourcing and off-shoring. Governments place increasing confidence in market forces to reflect public priorities, even as new paradigms such as open-source software and open-content knowledge and learning challenge conventional free-market philosophies. Yet it is also a time of unusual opportunity and optimism as new technologies not only improve the human condition but also enable the creation and flourishing of new communities and social institutions more capable of addressing the needs of our society. Both these challenges and opportunities suggest that major changes are necessary in engineering practice, research, and education in the century ahead, changes that go far beyond conventional paradigms.

Inspite of numerous achievements and successes in engineering education in India, many more challenge and opportunities are yet to be addressed. The development of engineering profession requires that these challenges are properly addressed and opportunities fully assessed and exploited beneficially wherever possible. It is also essential that the future trends are tracked and speculated in a reasonable manner. Given the multitude of ways that engineering education supports the profession, it is important that challenges and opportunities facing engineering education and possible future trends be understood and acted upon. If challenges are properly addressed, opportunities optimally exploited and future trends clearly anticipated, to a large extent most of the evils of engineering education can be sorted out.

2.0. Challenges

The main challenges and threats considered here in the areas of curriculum, teaching and learning relate to quality, pedagogy and relevance. For example, achieving and maintaining high-quality engineering education involves that excellence exists across all existing activities in a given engineering program and striving for excellence in new areas. Further, it is desirable to avoid reducing the quality of existing activities when embarking on new initiatives, an appropriate balance needs to be struck between broad and general excellence and targeted areas of excellence.

Pedagogical challenges regarding teaching and learning, from the points of view of both the teacher and the student are to be addressed. Very often quality of the students is very bad. The students are so bad that they lack fundamental / basic knowledge both in Mathematics and Physics and make it difficult to teach. Another problem faced by the teachers is the existence of 3- 4 categories of students in a class. Out of these 3-4 classes, one section of students is extremely good, while the last category of students is very bad. The other two types of students are average or below average. In such a scenario a teacher needs to adopt different approaches to each category, which is not easy in a tight academic schedule of 16 -18 weeks in a semester. Therefore the biggest challenge before a teacher is to strike a balance between various categories of students and complete the syllabus in time.

Furthermore, the engineering programs need to improve student problem-solving and learning skills and instill ability to continue learning throughout his/ her career. The relevance of engineering programs offered by various Universities and their affiliated colleges is very often questioned by the stake holders as they are obsolete. In addition, engineering curricula must include appropriate space for basic sciences such as mathematics, Physics, Chemistry and other relevant courses including English, environmental science, engineering drawing etc., and are to be continuously improved and updated to maintain relevance and effectiveness of the courses offered. Apart from this, appropriate support personnel and well equipped laboratories and computer facilities are also to be provided.

There is also a need to enhance and expand design in engineering education by collaborating with industry. It is also important to see that the student design topics are real and based on the industrial related aspects so that the students get hands on experience and makes them to understand the subject easily. Finally, the present day engineering students are expected to have leadership qualities, an ability to work in teams, strong communication skills, and an understanding of economics, business, management and entrepreneurship apart from risk management. Therefore, there is a need to provide enough space for these also in the curricula.

2.1. Improving the quality of teaching and teachers

The greatest challenge facing the engineering education in this country is the chronic shortage of qualified and eligible teachers in various subjects especially in Mechanical and Civil engineering subjects. Most of the Universities and colleges recruit the teachers based on their qualifications such as M.Tech. or Ph.D. degrees in their discipline but not based on their background in pedagogy. While conducting the interview, much of the emphasis is on perceived potential as a researcher. Candidates often give seminars on their research topic and if they can answer a few questions it is assumed that they are good enough for the teaching position. As the

time passes, some of them become good teachers by instinct and others learn their craft after several years of trial-and-error effort while a lot more never rise above mediocrity and end up as very bad teachers.

Teaching is a complex craft, but the skills required to do it effectively can be taught. The subset of teaching improvement are the organization of workshops, courses, seminars, mentorships and partnerships, learning communities and consultation with the experts in teaching. The institution should maintain resources for self-study, including books, journals, multimedia resources and information on useful web sites.

New pedagogies and methods for teaching to facilitate the learning are available, that can improve the outcomes of engineering education. Advances in information and communications technologies make it possible to use these tools in innovative ways in delivering education and facilitating and enhancing teaching and learning. Another approach to the teaching and learning methods in engineering education is to create virtual and simulated laboratories. These processes play an important role in facilitating distance education, thereby supporting lifelong learning. An additional benefit of this trend is its ability to offset the increasingly prohibitive costs of laboratory equipment. The trend is mainly to motivate the teachers about the importance of virtual design and computer simulation.

In a rigid curricula offered by several Universities in the country, the students have little opportunity to develop a wider range of transversal skills, including critical thinking, analytical reasoning, problem-solving and collaborative working. Therefore, the undergraduate programs should be reconfigured as an academic discipline, similar to other disciplines in sciences, arts, and humanities, thereby providing students with more flexibility to benefit from the broader educational opportunities offered by the General University system such as Choice Based Credit system (CBCS) with the goal of preparing them for a lifetime learning rather than professional practice.

It is widely recognized that the affiliation system often represents an impediment to overall quality development in engineering education in India because affiliated colleges cannot fully exercise academic, financial, and management autonomy under the system. Thus, one University has more than 600 affiliated colleges and because of this, the quality in planning, regulation, and supervision is usually not maintained by the affiliating Universities. As a result, curricula are often obsolete, the skills of the taught are usually not matched with the demand or local needs, the number of the faculty is totally inadequate and the quality of teachers is far below the normal standards.

3.0. Threats

Even in China, the number of institutions offering engineering degrees is only 570. In contrast, the number of engineering colleges in India is 3,400 with a capacity to accommodate 1.5 million students [1]. The mushrooming of engineering institutions in India has resulted in a low number of students and faculty per institution: 450 and 20, respectively. Secondly most of them offer undergraduate courses and as such the strength of the undergraduate students is very large when compared with that of post graduation. Similarly, the number of students registered for their Ph.Ds in India is 1,000, when compared with 9,500 in the United States and 17,000 in China as per 2010 stastics [2] . Further, even among those pursuing Ph.D., degrees the quality of research papers, research reference citations, patents etc., is very poor and needs improvement.

Therefore, one may conclude that although there is an undergraduate boom in the country, there is complete gloom on the research front and is the biggest threat to engineering Education.

There is a systemic segregation of teaching and research. Most teaching focused universities do not provide students with research experience or the skills which would prepare them for research careers. The causes, among others, stem from a lack of multidisciplinary working, no development for faculty and students in areas to stimulate innovation and few links with industry. These constraints reveal themselves in the failure of Indian Universities to make their mark in the world global rankings.

One of the most critical elements of the innovation process is the long-term research required to transform new knowledge generated by fundamental scientific discovery into the innovative new products, processes, and services required by society. In recent past this applications-driven basic research is the primary concern of corporate R&D laboratories, national laboratories and IITs. However, in today's world of quarterly earning pressures, there is a need for long term, applications driven basic engineering research. Unless urgent steps are taken to encourage research at all levels including in private engineering colleges, the entire engineering and science education in the country may have to face biggest ever threat.

4.0. Opportunities

Although, there is a tremendous improvement in all the aspects of engineering education, a lot more is there to do in order to achieve excellence in the field. For example, there is a need to continuously interact with the industry almost on a daily basis. Further, the barriers between traditional engineering disciplines and other subjects should be dissolved so that new disciplines including interdisciplinary and multidisciplinary engineering programs emerge. For example, the interdisciplinary approach strengthens the existing areas and the linkage between nanotechnology and medicine may yield new advances in health care. In addition, the linkages between engineering and management are beneficial especially to the industry and may result in the emergence of a new program - engineering management. One may also think of new branches in engineering such as nanotechnology, computational engineering (which focuses on the use of computational methods in various engineering disciplines) health engineering, genome engineering, and engineering for sustainable development & sustainable energy etc.,

5. 0. Future Trends

Engineering education has evolved since its origin and one of its strongest features is its resilience and flexibility and its ability to adapt and evolve as new challenges, opportunities and new realities become apparent. The main future trend in the engineering education relates to creativity, innovation, design, engineering methods and fundamentals. Therefore, there should be a greater focus on creativity and innovative approach, as traditional engineering programs become out dated and irrelevant. These attributes can help in keeping them in the forefront of engineering profession and this trend will yield more competent and productive engineers.

Another trend is to increase the focus on engineering methods and fundamentals, with a corresponding reduction in discipline-specific course content. Although by increasing the discipline-specific content in engineering programs along with new technologies will motivate the faculty members, such a response is unsustainable, as it usually leads to overly compressed curricula. Thus, the discipline-specific content cannot be covered in a 4 year engineering undergraduate program Therefore, the focus should be more on fundamentals and engineering methods and approaches, which tend to provide students with the tools need to address discipline-specific tasks. In fact, much of the discipline-specific knowledge can be attained in the workplace by networking through face-to-face and virtual communities of practices and via lifelong learning process. This approach will improve the core ability of an engineer to solve problems and address opportunities, regardless of the specific topic at hand. The future engineers will have to learn on the job as everything cannot be covered in a program.

5.1. Enhancing Professionalism

There is a need to change the mind set of engineering Graduates so that they can understand the importance of professional ethics, attributes, business, management, entrepreneurship and globalization. A greater focus in engineering curricula should be such that the engineers behave ethically correct and respect their duty to protect the public, especially in light of the seriousness of the potential dangers of unethical practices in engineering. Focus should also be there on maintain the high quality professional integrity in the present scenario of strong public disapproval when inappropriate practices are revealed in public or private sector organizations.

Another professional attribute is the communications skills. Engineers' abilities to communicate effectively not just with each other but with others in companies and the public necessitate strong communications skills and employers increasingly expect such skills. Engineering programs are to be expanded to cover business management and entrepreneurship, so that they can work more productively in organizations and companies, be more effective if they take up managerial or leadership roles and become entrepreneurs by developing engineering innovations with good potential for commercial success.

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