12. ENGINEERING EDUCATION IN INDIA – AT CROSS ROADS

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1.0 Need for Quality Engineering Manpower for growth of India

Technology has been and will continue to be a prime driver of Quality of Life and Economic growth. In order to achieve 7% GDP growth on a continuous basis and be competitive in the global economy, India needs quality Engineering Manpower in not only in manufacturing sectors of the Economy like Automotive, Consumer electronics, Heavy Engineering, IT ,ITES, Oil and gas, Pharmaceuticals, Power, Real Estate, Telecom etc but also in service sectors like banking, insurance, hotels, Hospitals etc. Requirements for Engineers span across technical functions (like R&D, product design and development, construction, manufacturing, maintenance, customer service and software development) as well as techno-commercial functions (like sales, feasibility studies , credit appraisals, risk assessment and mitigation etc).

2.0 Trend of enrollments in Engineering Colleges

There has been about a three fold growth in the number of UG Engineering seats in the country, in the last five years, growing from 6.5 Lakh in 2007-08 to over 18.5 Lakh in 2012-13 (Exhibit 1). During the same period, capacity generated in Private Engineering Colleges went up steeply by five times. Now, over 3/4th of the Engineering Institutions are private. During 2011-12, over 5,190 engineering colleges admitted

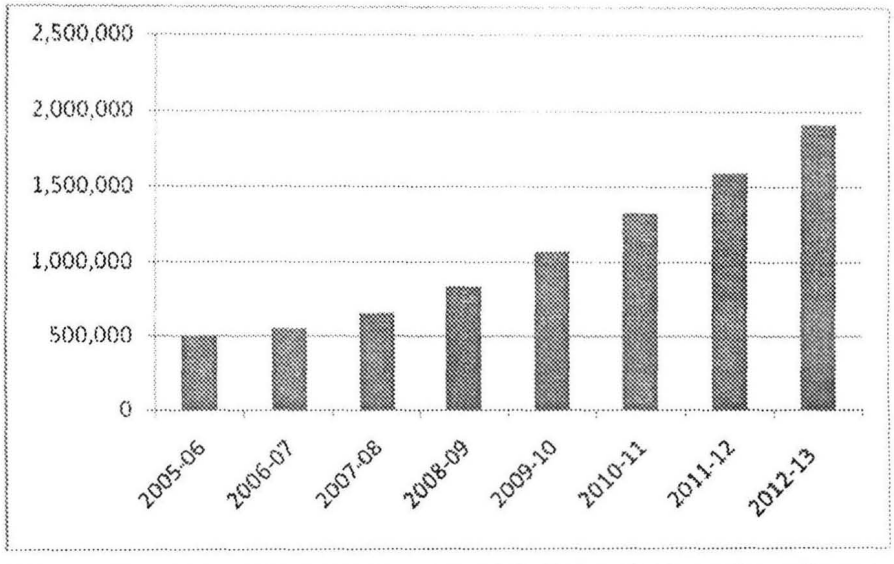

Exhibit 1: Trend of capacity of Engineering Institutions in India (UG seats) , Source: Cygnus Research

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14.86 Lakhs of students, which includes 30% girls, which increased from 20% about 5 years back. The Institutions include 17 Premier Engineering Institutes (15 IITs, IT-BHU and Indian School of Mines), with a capacity of 9,647 seats, for which 4.8 Lakh students appeared for the IIT-JEE competitive examination during May 2012 and 31 NITs ,with a capacity of 35,000 seats, for which over 12 Lakh students appeared in the AIEE Examination in May 2012. Currently, over 200 Entrance tests are conducted across India to admit students into Engineering UG Degree programs.

However, capacity of Engineering seats is not evenly spread across the country. As can be seen from Exhibit 2, about 47% of the Engineering Colleges (and over 50% of seats) are located in South India , with AP having a lion's share of about 17% ,whereas the entire East and North East contributing only 8% of the colleges. This has been forcing the students from the Eastern and North Eastern regions to migrate to the other regions for pursuing studies.

Exb 2: Region wise number of Engineering and Technlogy Institutions

Region	Major States covered	Total	% of total	Private (unaided)	% Private
1 East	Orissa,West Bengal, Jharkhand and North East	422	8%	284	67%
2 South	Tamil Nadu, Pondicherry	955	18%	864	90%
3 South West	Karnataka, Kerala	598	12%	333	56%
4 South Central	Andhra Pradesh	900	17%	759	84%
5 Central	MP, Gujarat	540	10%	365	68%
6 West	Goa, Maharshtra	750	14%	657	88%
	Bihar, UP, Uttarchnal, Delhi, Punjab, Haryana, J&K, Rajasthan, Chandigarh,				
7 North	Chattisgarh	1029	20%	824	80%
Total		5194	100%	4086	79%

Source: AICTE Website as on 27th Jun 2012

The paradox is: while there is intense competition for admission into Premier colleges like IITs and NITs, wherein one in 1 in 50 students and 1 in 35 students is selected, respectively, it is understood that during 2011-12, over 20% of the seats in tier-3 colleges could not be filled up and some colleges could fill up only less than 25% of the seats. The situation may not be any better during 2012-13. This situation has forced AICTE to consider not to give approvals to new Engineering colleges from 2014 onwards. This is a grave situation that needs careful analysis and quick addressal.

3.0 Low level of employability due to Skill gaps :

On the other hand, while the industry needs a number of qualified Engineering Graduates, as per various surveys, on an average, hardly 25% of them are employable. As per a survey of employment of Technical Graduates in IT/ITES industries, employability in Technical support and IT services is only 25.9% and 17.8% respectively. As we move to more technology intensive roles like KPO and product design, it drops down to as low as 9.5% and 4.2%. Likewise, the figure goes down as we move to tier-2 colleges. Industry finds that it is 3 times more difficult (in terms of efforts and cost) to identify an employable graduate from tier-2 campus , compared with a tier-1 campus, with the result, most of the companies stopped recruitment from tier-2 colleges. It was noticed that there was a significant skill gap between the students from top 100 tier-1 colleges and the rest of the colleges , in major areas like Quantitative ability (Mathematics skills) , English Communication and Logical ability.

Even the students that are selected by the IT companies have to be trained by the companies for periods ranging from 6 to 9 months, before being deployed on the jobs. Currently, IT industry alone spends about Rs 6,000 crores per year on these training programmes, for which large training infrastructure was set up, including thousands of full time faculty members.

Companies from other industries also face similar challenges with regard to recruitment and training of fresh Engineering graduates. As per Prof LN Mittal, , the industry expects the Engineering Graduates to possess the following skills :

1. Acquisitive capabilities: the capability to acquire knowledge/technologies for effective functioning in various functional areas.
2. Adaptive capabilities: the flexibility of adopting new methods and techniques.
3. Operative capabilities: the know-how of production/ fabrication/installation practices, codes and standards, production engineering, diagnostic and managerial skills.
4. Innovative capabilities: ability to anticipate future demands and to develop new design, processes, technologies and systems.

4.0 Issues in the current Engineering Education in India

Let us analyse the issues, contributing to this situation in Engineering Education in India.

4.1 **Obsolete Curriculum:** In the last few years, there have been breath-taking advancements in Technology all over the world. Nano technology invaded and has its foot prints in a range of diverse application areas. Convergence of technologies (like ICT) and Multi-disciplinary technologies (like Mechatronics and Opto-electronics) have impacted product innovation in a big way. While the industry embraced these developments to retain their competitiveness and productivity of labour and capital, curriculum for Engineering Education in India has not undergone any major change in the last few years. Now, the industry expects the graduating students to be familiar with the same developments.

4.2 **Lack of Soft infrastructure:** Primary concerns of the Institutions as well as the regulators like UGC and AICTE continue to be hard on infrastructure like land, buildings and equipment, soft Infrastructure like Curriculum, Pedagogy, Course material, Knowledge Resources (like online libraries), deployment of technology etc have received less focus , though they can make a profound impact on the learning effectiveness of the students.

4.3 **Quality of delivery:** Learning versus Teaching: In the last few years, there has been a paradigm shift in the profile of the

students (Learners). The Y-generation was born and brought up the technology era, so much so that, technology devices like mobiles, internet, social media etc are part and parcel of their day-to-day life. So, are their ways of learning and keeping themselves updated with the latest developments. However, pedagogy did not keep pace with these changes in the student profiles.

4.4 **Mismatches:** On one hand, there is a huge gap between the skills requirement of graduating Engineers versus the expectations of the industry (in not only professional skills but also in soft skills). On the other hand, there has been a disconnect between manpower requirement by the industry and manpower generation. Until recently, irrespective of the specialisation in Engineering, all students have been aspiring for jobs primarily in IT industry, lured by high salaries due to large supply-demand gap. Of late, a lot of employers as well as educators are realizing that the students also need to be given inputs in professional ethics and human values , in addition to knowledge and skills, to make them successful professionals

4.5 **Inadequacy of faculty** is on two counts - quantity and quality. During the first week of August 2011, Parliament was told that there is a shortage of over 1.5 lakh teachers in Engineering colleges against a requirement of 2.8 Lakh teachers needed, on the basis of a teacher, student ratio of 1:14, as stipulated by AICTE, shortage of faculty has increased to 54% from 30%, about 5 years ago. Even the premier Institutions like IITs and NITs, are not exception to this, as they are yet to fill up over 3,200 vacancies. Every college is fishing for faculty in the limited supply pool, which has not kept pace with huge increase in admissions. Intake for MTech/ME has not been increasing faster and the country currently produces about 1,000 PhDs in Engineering per year, which is woefully inadequate. This led to a situation wherein a number of Engineering faculty members in recently set up colleges are not even Post Graduates. Besides, most of the Institutions are unable to attract experienced faculty members from the industry, as salary levels and work environment are not on par with the industry.

4.6 Ineffective Governance in some of the lower rung Institutions is evidenced in the conduct of classes, examinations, maintenance of student discipline etc, The steep rise in admissions for Engineering has not kept pace with increase in generation of academic leaders, which is critical for maintenance of educational standards

5.0 Suggestions to address the issues

The current situation calls for a major re-engineering of the Engineering Education in the country.

While there are areas of policy and regulation, which need intervention from Government, there are a number of areas, which can and need to be addressed by the Institutions themselves. Following are a few such areas:

5.1 Introduction of contemporary job oriented programs;

According to Dean Bugliarello, the following are the major trends that are affecting the Engineering Education:

i) Technical factors :

- New physical frontiers, dimensions, speeds and power. Space Technologies, Nano technology and Photonics fall into these categories.
- Convergence of Engineering and Science: They include areas like Bio-technology (wherein biology blends with Engineering) and Bio-medical, giving rise to applications like development of Artificial organs, Novel Drug Delivery Systems etc.

- Multi-disciplinary designs: wherein diverse Engineering disciplines like Mechanical,. Electronics, Civil, Biological, Chemical etc mesh in to create innovative products in areas like Mechatronics, Intelligent Security systems, Intelligent buildings, and Artificial Intelligence devices.
- Intelligent and Multi-functional artifacts : Smart materials, Smart products, self-diagnosing products etc
- Rapid growth in Information Technologies
- Information explosion
- Gobalisation and re-organisation of Engineering processes, wherein multiple stake holders like Engineering and Business teams, Manufacturers and vendors across the globe work together on a co-operative basis, enabled by advances in IT and Telecom

ii) Economic factors : which include aspects like competitiveness and cost reduction

iii) Social factors: which include Concern for the Society and Concern for the environment

iv) Political factors: Cessation of cold war, Downfall of communism and dictatorships have given rise to a more open global economy.

v) In view of the above, curriculum needs to be reformed, taking into account all the factors so that it is contemporary and make the graduating Engineer not only job-ready but also productive from the day One. The new curriculum should include more interdisciplinary elements and interfaces, exposure to industry through project based learning and internships, interpersonal skills, more knowledge on general management, business process skills. The program should be more flexible so as to facilitate joint/ twinning programmes with foreign universities. Some engineering colleges have already made a beginning by launching innovative specialisations / electives like Mechatronics, Nanotechnology, Opto-electronics, Bio-informatics etc, by collaborating with industry. Some colleges have introduced more management and finance courses so as to make the Engineer more techno-commercial and entrepreneurial. Some colleges have launched Integrated dual degree programs (like MBA/BTech).

5.2 Focus on Skills: After the graduation, a student may opt to join a job, be an Entrepreneur or go for higher studies (India or abroad). Skills that are imparted to the students should cater to all these three career choices.

5.2.1 As Engineering is a professional qualification, the industry expects the graduating students to have professional skills, besides knowledge. Professional skills can be imparted only through hands-on practice, by exposing the students to projects and internships in industry, under the guidance of faculty guides and industry guides. Various surveys have shown that most of the Engineering graduates lack soft skills, like positive attitude, communication, presentation skills and team working. Soft skills can be imparted only by continuous training and practice by the students under the guidance of Soft Skills trainers. There is a further imperative to inculcate professional ethics and human values, in order to make the graduating students successful in their careers.

5.2.2 Current Engineering Education is not adequate to make the gradating engineers as Entrepreneurs, which needs additional skills like marketing, finance and people management. This could be addressed by offering more electives under Management.

5.2.3 With increasing globalization of businesses, more demands are made on Engineering Professionals that aspire to study abroad or work in the global environments. They include international outlook (and understanding the implications of developments in economic and political

arenas), appreciation of (and sensitive to) local cultures and values and adaptability to work in multi-national and inter-disciplinary teams. Tie-ups with foreign universities and industry-academic partnerships with MNCs can help in building global perspectives among the students.

5.3 Augmenting Faculty resource pools :

5.3.1 Currently, number of seats for M Tech / ME programs Is a meager 5-6% of the seats for B Tech programs (See Exhibit 3) . There is need to increase the capacity for M Tech / ME programs, particularly in the premier Engineering Institutions, besides allowing more reputed Engineering colleges to offer the PG Programs. At the same time, the programs have to be structured more innovatively, in collaboration with the industry

5.3.2 Number of seats for PhD in Engineering is abysmally low and has been practically stagnant for the last few years, as can be seen from Exhibit 3. No wonder, during 2010-11, only 1,007 PhDs were produced in Engineering, which is woefully low, compared with the requirement. There is also need to enhance the number of PhD enrollments by more Universities offering part time PhD programs so that faculty members as well as practicing managers from industry can pursue PhD programs in Engineering.

5.3.3 Engineering Institutions should encourage alumni and other experienced professionals from industry to take guest lectures for the students. This can be mutually beneficial to the industry as well as Engineering Colleges

5.3.4 Engineering colleges, at a regional level, can also consider pooling and sharing faculty members in certain critical areas, to start with and gradually help augmenting the same by way of faculty development programs.

5.3.5 It is equally essential to make the teaching profession more attractive to the qualified and experienced Engineers so that the resource pool is not only enlarged but also enriched. Professional and challenging work environment is as important as compensation. Consulting opportunities along with attractive sharing of consulting revenues with the concerned faculty members can help not only in attracting the competent professionals but also keeping them abreast of the technological developments

Number of Seats approved by AICTE for Engineering Programs

Type	2011-12	2010-11	2009-10	2008-09	2007-08
UG	10,66,489	9,62,150	7,84,170	6,07,673	4,73,102
PG Degree	61,029	47,378	34,788	29,342	25,303
As % of UG	5.7%	4.9%	4.4%	4.8%	5.3%
PhD	367	367	325	305	305
As % of PG	0.6%	0.8%	0.9%	1.0%	1.2%

Exhibit 3 Source: AICTE Website,as on 27th Jun 2012

5.4 Improving effectiveness of existing faculty members

5.4.1 Training / Re-training of existing teachers, in technology areas as well as in modern pedagogy, can go a long way in improving the quality of the resource pools. Premier Engineering Institutions as well as industry can help in this aspect. Under the National Mission on Education through ICT, IIT Mumbai has been conducting workshops to train 1000 teachers at a time . The Institute has now expanded the model to make it a program for training 10,000 teachers at a time, wherein faculty members participated in the programme from 168 locations in the country. Lectures for this course were delivered by professors from IIT, Mumbai and Chennai.

Besides subject knowledge, faculty members also need to be trained on pedagogy, in particular, on usage of technology in teaching. Recently, more than 600 teachers from private engineering colleges in Andhra Pradesh were trained by AP State Council for Higher Education (APSCHE) on how to make better usage of technology for teaching and improving their teaching skills using the courseware offered by the world's top institutes like MIT and Stanford, apart from NPTEL. Most of these teachers did not have an opportunity to study under good teachers. So, the training opened a new world to them on how teaching can be made more effective by acquiring new skills. They learnt how the topics were presented by good professors and now, they have more confidence to face the students

5.4.2 Faculty members should be encouraged to appear and qualify for National Eligibility Test (NET) (conducted by UGC) and State Eligibility Test (SLET) examination, which will help them to be abreast of the subjects being taught by them

5.4.2 In the last few years, Internet facilitated sharing of knowledge created across the globe. Open Course Ware (OCW) is a free and open digital publication of high quality college and university-level educational materials. These materials are organized as courses, and often include course planning materials and evaluation tools as well as thematic content, in a variety of formats (Text, Multi-media, Video lectures etc). Most of them are free and openly licensed, accessible to anyone, anytime via the internet. Besides retraining themselves, Faculty members can embed this material to enrich their lecture sessions.

5.5 Technology-Enhanced Learning

Advances in IT and telecom technologies are bringing in a paradigm shift in the way a student can learn more effectively. Multi-media can help the student to learn concepts more clearly. Simulation models can enable more students to work on virtual prototypes and gain practical skills. Besides, the student can learn flexibly as per his convenience. Recently, MIT and Harvard, announced launch of free online courses in five disciplines, including Engineering. A few months earlier, a consortium of Stanford, Princeton, University of Pennsylvania and University of Michigan announced Online programs. Going by the excellent response they received, it appears that future of teaching in Engineering Colleges will be a blend of class room teaching and technology enhanced self learning. Online presentations and Video lectures by professionally trained presenters will supplement the class room lectures and tutorial sessions. Already in some Institutions abroad, both learning and assessment are increasingly through peer to peer via social networks, with faculty members acting as facilitators and mentors. Indian Engineering Education needs to gear up itself for these breath-taking developments. In a way, Technology can be advantageously used in tier-2 and tier-3 location, to address the shortage of competent teachers , by supplementing the existing faculty resources.

5.6 Industry Partnerships

In order to make the graduating students more employable, it is critical that the Engineering Institutions build close collaboration with industry. This type of collaboration can help in updating the curriculum and arranging for guest lectures by experienced professionals. It can also help in organising for internships and projects for the students so as to impart hands-on skills to the students. MNCs like IBM, Microsoft, SAP, Oracle, Intel and Nokia have worked out a range of industry-academic collaboration programmes, which need to be leveraged by the Institutions. For instance, Infosys, during 2011'-12 trained 7,200 faculty members and 1,53,000 students to improve employability of Engineering students. Likewise, Mahindra and Mahindra launched an initiative called "Auto Passion" to spread awareness on Automotive industry and covered 400 Engineering Colleges across the country. They are all opportunities for Engineering colleges to participate actively. In another example of industry-academia interface, the public sector Bharat Dynamics Ltd (BDL) is planning to set up of a Centre of Excellence in the BITS, Pilani, Hyderabad Campus. As per the MoU, BDL and BITS will engage in collaborative research in areas such as digital image processing, embedded systems, VLSI design, information security and management, seeker technologies, etc. Some of the colleges/ Universities induct senior managers from the Corporates onto their Corporate Advisory Board.

5.7 Academic Processes

While academic processes / procedures of most of the Engineering Institutions look very good on paper, it is the stringent implementation of those processes that will make a real difference to the quality of learning of the students. It is all the more important for mid-tier and low-tier Engineering Colleges , which find it difficult to attract very meritorious students. Diligent monitoring of academic processes like student attendance, faculty sessions on schedule, quality of delivery, counseling of errant students and faculty members can do a substantial "Value Add" and convert "average" students to "extra-ordinary" performers, it is these students that can be the "Brand Ambassadors" for the college and enable it to move up the ladder.

5.8 Academic Leadership

While teaching is the 'bed-rock" of any Engineering Institution, there is need for good leaders to help the Institution become more successful. There is need to identify and groom faculty members in other critical areas like overseeing / supervising academic processes, extra-curricular activities, student counseling, faculty recruitment and training , alumni relations , industry partnerships etc. Besides helping to build the Institution , it will also build leadership skills of the faculty and prepare them for better careers. This need is all the greater for private Engineering Institutions, as they face multifarious challenges on a day-to-day basis.

5.9 Quality Accreditation

Accreditation gives an assurance that the college met certain quality standards and helps the students to enhance opportunities for employment as well as higher studies (particularly abroad). There are renowned agencies (from both India and overseas) that review the Institutions from multiple perspectives and accord Quality Accreditation. This helps the Institution to identify its areas of weaknesses and put in concerted efforts to improve itself. It is rather surprising that less than 20% of the Engineering Colleges were accredited by NBA (the accreditation organisation of AICTE) and NAAC (the accreditation organisation of UGC). VIT University and SRM University got some of their B Tech

programmes accredited by ABET (Accreditation Board for Engineering and Technology) . ABET is an international federation of 30 professional and technical societies and has reputation of being an independent body, setting international standards in science and technical education.

Recently, AICTE in collaboration with CII, announced a survey of best practices in Engineering colleges and is planning to give away awards to the "best in breed" colleges (Best Engineering Institute as well as stream/branch wise best Institute) as well as faculty members. Likewise, Engineering Colleges can bench mark themselves with premier colleges in India and abroad, with a view to identify areas for improvement.

5.10 Tie-ups with Foreign Universities

While tying up with Foreign Universities, it is as important to identify the right partner, as it is to clearly identify the areas of "Value Add" for the students and take steps to realize them. The areas of collaboration could be twinning programmes (award of degrees by both the Institutions) , formulation of curriculum , course material, exchange of faculty, exchange of students and training the faculty members ,which will help in improving the quality of education. As per a study conducted by Association of Indian Universities (AIU), 631 foreign education providers were operating in the country in 2010, out of which only 60 had programmatic collaboration with local institutions and 49 were operating under twinning arrangements. Experience has shown that it is a challenging task to build and nurture ties-ups, which are mutually beneficial (for both the Institutions).

5.11 Globalisation of Engineering Education

In order to provide mobility and interchangeability to the Engineering Qualifications across the world, there are three agreements covering mutual recognitions , which include the Washington Accord (1989) The Sydney Accord (2001) and the Dublin Accord (2002) , India , represented by AICTE, is a provisional member of the Washington Accord. and is expecting to become a permanent member by June 2013, A permanent membership would mean that undergraduate Indian Engineering courses will be brought on par with US, UK, Japan, Australia, Singapore ten other countries. The full-time membership will result in enhanced accessibility of higher education and jobs abroad for Indian students. It also will open doors to more overseas students to pursue Engineering education in India

6.0 Conclusion :

India has the second largest Engineering Talent pool in the world and Indian Engineers having been doing a lot of pride to the country, wherever they are. The credit goes partially to the quality of education , they received. However, in the last few years, due to massive expansion, quality of Engineering education got diluted. Through re-engineering and innovation , Engineering Education in India can regain its place not only in India but in the entire world. India Inc will be eagerly looking forward to it, as growth of India hinges a lot, on it.

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