Engineering Education in India: Past, present and future

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Abstract

The article is about how engineering education evolved in India along different models, the present scenario and the future roadmap. A comparative analysis has been done on an international basis regarding growth of technical education, curriculum, and accreditation and assessment procedures also – so that our global position is improved in technical education, thereby ensuring the growth of our economy.

There are strengths as well as weaknesses of the Indian technical education system. At present, India is producing a technical manpower of about 5-6 lakh. However, even with a 9% GDP, India ranks very low in HDI or knowledge economy index. Innovation is not a strong point of India's technical education system. That needs rectification.

The identification of weak points being imperative and immediate, the article attempts to make some conclusive remarks so that the technical education scenario in India can be improved and India can take a globally relevant seat in the engineering educational institute rankings.

Keywords: *engineering education, India, growth, future roadmap, curriculum.*

1.0 Growth of Technical Education in India : different models

The study of the origin and growth of technical education in India shows that it took different routes: the colonial model, the nationalistic model, the research model, the university model, the IIT model, etc. Initially it was the colonial model, in which colonial rulers wanted to train the countrymen as subservient workers only. Five engineering colleges, namely, Guindy College of Engineering (1858) in Madras (now Chennai), Thomason Civil Engineering College (1847) at Roorkee, Poona Engineering College (1856) at Poona (now Pune), Calcutta Civil Engineering College (1856) in Calcutta (now Kolkata), and Victoria Jubilee Technical Institution (1887) in Bombay (now Mumbai) were established to produce 'technical hands' for the empire. The curriculum and the training in these colleges were geared mostly to meet the requirements of only subordinate grades of engineering services of the then British colony, India.

In the early twentieth century, nationalistic models developed. One attempt was the setting up of the National

Council of Education, Bengal in 1906 by the nationalists, which later became Jadavpur University. The second one was Banaras Hindu University in 1916 by Madan Mohan Malaviya, where courses in technical education, law and medicine were imparted together with the inculcation of the spirit of Hindu religion 'for moral growth'. The growth of this model, carried on by dedicated *swadeshis* was done without any government help in the initial stages. However, the quality of education got recognised all over world.

Apart from the *swadeshis*, there were some individuals and industrialists through whose efforts and financial help technical education did make immense headway in India. The first research institution, the Indian Association for the Cultivation of Science, was started in Kolkata in 1876 by Dr. Mahendralal Sarkar. Another was the establishment of the Indian Institute of Science in Bangalore in 1909 by the industrialist J.N. Tata as a research institute where post-graduate and research courses were offered.

The universities were primarily imparting arts and science education in India from 1857 and were affiliating bodies. There was no roadmap for growth of technical education in the universities. It was only in 1951 that the first Indian Institute of Technology (IIT) was established with foreign collaboration, exclusively for undergraduate and post-graduate level technical education, based on the Sarkar Commission Report (1946).

2.0 University and Technical Education system

The university system in India started in India in 1857, and 150 years later we have only about 400 of them. After Independence, there has been a phenomenal increase in the number of universities, but the quantity and quality is still inadequate.
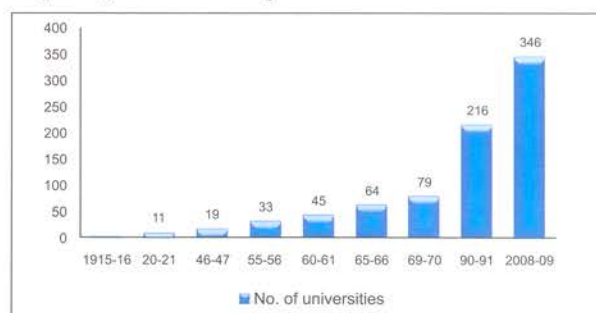

Fig. 1: Growth of the universities in India

The number of universities has increased from 25 in 1950 to 346 in 2008; number of engineering degree level institutions has increased from 44 to 1,668; and the number of colleges has increased from 700 to 18,064, with the enrolment from 0.1 million to 11.2 million. But the Gross Enrolment Ratio (GER) is quite low relative to the other developed and developing countries. The GER in the USA, UK, Japan and Australia are 83%, 60%, 55% and 72% respectively. The Government has set a target to increase GER to 15% by the end of 11th plan and 22% by the end of 12th plan.

A major problem hindering the excellence of the Indian universities in the past was their affiliating nature. Earlier ones were modelled mostly on the British universities and majority of them were affiliating and examining universities, not teaching universities, let alone for conducting research. Postgraduate work was confined to the colleges, which were not properly equipped for such work and so the quality of postgraduate work was not of a very high order. The university curricula were inadequate to meet the needs of a scientific and industrial age. Thus the universities in the early stage, failed to contribute much to the advancement of knowledge in India, which was surely one of their obligatory functions. When Bombay University was established, it had no faculty of science and the only course in engineering was in civil engineering. Kolkata grew with a strong science base. However, the progress of technical education was hampered due to the lack of government support and funds as also an alienation of the university model from European and American ones in particular, which were research and industry oriented and professor centric rather than bureaucracy centric.

Though the universities offered a programme of undergraduate studies in pure and applied sciences, enrolment in these courses throughout the nineteenth century was very low, because, opportunities for Indians to advance in the scientific services were limited by colonial rulers. Most students preferred arts courses or professional courses like law and medicine. This was one main reason that hampered the growth of higher scientific and technical education within the domain of the university system.

Based on Prof. A.V. Hill's report in 1944, *Scientific Research in India* many research laboratories were created. A large pool of scientists from the universities was absorbed into the research laboratories, delinking research and teaching. Delinking of teaching and research has been one of the reasons for lack of availability of good faculties (P.Balaram, *Curr. Science,* **97**, 2009). Without the capability of knowledge generation, knowledge dissemination becomes difficult for a faculty. However, the indigenous growth models in space, atomic and defence research has been build up with inputs from our Institutions and have put India at par with global superpowers.

Some of these universities became the cradles of technical education in India, but not technical institutions, up to 1960s, till the Kothari Commission report came out. The universities of Calcutta, Bombay, and Madras, Banaras Hindu University, Aligarh Muslim University, Roorkee University, Anna University, Jadavpur University, and Bengal Engineering and Science University were some of them. Recently there has been a spurt in the growth of private, deemed and affiliating universities – whose qualities are questioned by the authorities themselves. Research universities need to be developed in India. A study is given below:

Table 1: Strengths and weaknesses of the university Research & Development system

Strengths	Weaknesses
* Continuous availability of students. * The academic ambience and peer groups in good universities facilitate objective inquiry. * Peer pressure and promotional requirements provide motivation for the faculty to be productive. * Availability of large body of peers with a wide spectrum of specialisations has the potential to promote interdisciplinary research. * Necessity to undertake sponsored research and consultancy promotes R&D on live problems pursued by national R&D agencies and industry. * The friendly rapport with international peers promotes international collaboration, which is difficult outside the university system.	* The manpower opting for research in recent times is essentially composed of those who could not find jobs. * It is relatively difficult to keep computing and experimental infrastructure up-to-date, at least in State universities. * More of incremental type of research than innovative. * Interpersonal relationship, credit sharing, etc., create problems for team work. * Outputs are more theoretical, not practical. * Research works get hampered because of the load of teaching.

[Source :Natarajan R., *The Indian Journal of Technical Education,* 2006]

An international comparison of engineering PhD outputs is shown in the following figure.

Fig 2: Engineering doctorates of different countries

[*Source*: Banerjee R, Mulley V (2010)]

The percentage of engineering PhDs as compared to Bachelors of Engineering degrees granted annually is given in Table 2. The percentage in India in 2002 was 0.66%, while Germany, UK, and USA maintained rates of 7-9%. China has increased engineering PhD output significantly in the last few years.
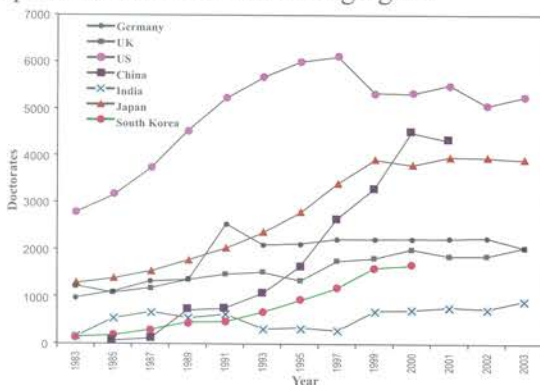
Table 2: Percentage of Engineering PhDs compared to Bachelors of Engineering degrees.

Country	1983	1985	1987	1989	1991	1993	1995	1997	1999	2000	2001	2002
Germany	4.41	4.70	5.39	5.23	8.66	7.66	7.70	8.05	8.87	8.92	8.97	6.81
United Kingdom	0.11	11.11	12.84	13.75	14.89	7.66	6.02	7.65	8.22	9.78	9.08	9.17
United States	0.04	4.08	4.99	6.79	8.38	9.09	9.48	9.81	–	8.94	9.28	8.36
China	–	0.09	0.15	0.65	0.67	0.88	1.11	1.51	1.67	2.11	1.98	–
Japan	0.02	1.93	2.01	2.30	2.32	2.67	2.87	3.31	3.80	3.68	3.79	3.81
South Korea	–	0.84	0.98	1.47	1.52	1.99	2.65	2.80	3.11	2.93	–	2.92
India	–	2.21	2.13	2.03	–	–	0.58	0.40	0.93	0.87	0.83	0.66

[Source : Banerjee R, Mulley V (2010)]

3.0 Indian Institute of Technology (IIT) and National Institute of Technology (NIT)

3.1 Indian Institute of Technology (IIT)

It was only after Independence that engineering and technological education got a great boost. Till the establishment of the Sarkar Commission in 1946 (the report was published in 1949) there was no specific thrust towards technical education in India. On the initiative of Sri Ardeshir Dalal, a visionary director of Tata Iron and Steel Company, the Government of India appointed the Sarkar Commission. The commission recommended the establishment of four institutes of higher education on the model of Manchester University (UK) and Massachusetts Institute of Technology (USA) to train scientists and engineers to support the economic and social development of India after Independence.

Though the first IIT at Kharagpur was established in 1951 with J.C. Ghosh as director, the IIT Act came into force in 1956. The other three IITs came into existence in a short span of a decade in Bombay (1958), Madras (1959), and Kanpur (1959). The College of Engineering, Delhi was converted into IIT in 1961. The five IITs had the benefit of assistance and partnership of foreign countries. Each IIT thus developed some of the culture of the assisting country – for instance, IIT Madras put heavy emphasis on workshop practice due to its tie up with Germany and IIT Bombay possessed heavy equipment. Though the traditions and conventions adopted by each of them are different, the spirit and approach to technological education is the same among the all IITs.

IIT Guwahati in northeastern India was started in 1994 and Thomason College of Civil Engineering became IIT Roorkee in 2001. In the 11th Five Year Plan, eight new IITs were sanctioned and IT-BHU has been converted in to IIT. The Indian Institutes of Technology Act has declared all the IITs "Institutions of National Importance".

During the last few decades, the IITs have contributed a lot to the upgradation and modernisation of science and engineering education in the country by bringing the concept of innovative, liberal and flexible academic systems. Considerable investment and effort has gone in to increase research activities, developing some centres of advanced research to give technological

leadership, and diversifying and expanding post-graduate engineering education. The autonomy and academic ambience created in these campuses have attracted the best faculty and students from all over the world.

The IITs have earned worldwide fame due to the sincere efforts of faculty, students and administration. The IIT system is one of the major success stories of independent India and ranks amongst the topmost institutions in the world in all ranking system of educational institutions. Self renewing process through continuous assessment of educational facilities and curriculum has proved to be a successful system. But how far the IITs have succeeded in conducting research and development at internationally competitive levels and succeeded in producing engineers 'on par with the best in the world' are the most frequently raised questions which is subject to further study, as India still remains a low ranked country in terms of technological education and research. Current figure shows that about 40 percent of the IIT graduates leave the country for higher studies or better job opportunities. Only a small percentage of the IIT graduates join the engineering sector, teaching, or R&D sector in the country.

To review the work and progress of the IITs, the Government of India had appointed the following committees:

*   Nayadumma Committee in 1984,
*   U. R. Rao Committee in 2003, and
*   Ramarao Committee in 2004.

The Ramarao Committee had highlighted several of the issues involved and made recommendations regarding governance, faculty matters, research enhancement, entrance exam, linkage with industry and funding policy, etc. For recruiting new faculty members, the IISc practices were considered more flexible system than the IITs. The committee made a comparison of the IITs and IISc practices in this regard and recommended that IISc system may be adopted by the IITs for faculty induction, assessment and promotion. The committees made several recommendations which are contradictory to each other and many are yet to be implemented.

Table 3 shows a comparative analysis for the research outputs of the Mechanical Engineering Department of different IITs and IISc, Bangalore compared to that of other foreign universities (based on publication record in the period 1993-2003)

Table 3.

Institute	Current faculty strength	No. of papers		Citations			Impact Factors		
		Total	Per faculty	Total	Per faculty	Per paper	Total	Per faculty	Per paper
IITB	46	71	1.54	381	8.28	5.34	40.09	0.87	0.56
IITD-ME	36	54	1.50	190	5.28	3.52	21.59	0.60	0.40
IITD-AM	24	44	1.83	315	13.12	7.16	24.11	0.88	0.55
IITK	35	164	4.69	731	20.89	4.45	82.65	2.36	0.50
IITKgP	43	97	2.26	503	11.68	5.18	2.56	0.54	0.54
IITM-ME	43	134	3.12	605	14.07	4.51	62.01	1.44	0.46
IITM-AM	18	89	4.94	353	19.11	3.97	54.85	3.05	0.62
IISc	29	196	6.76	873	30.10	4.45	159.50	5.50	0.81
Stanford University	61	1272	20.85	6952	113.80	5.46	-	-	-

3.2 National Institute of Technology (NIT)

During 1956-1960, Regional Engineering Colleges were established to cater to the projected growth of technical manpower in various states. Regional aspirations were given a vent. As per the Mashelkar Committee's (1998) recommendation, 17 Regional Engineering Colleges (RECs) were converted to National Institutes of Technology (NITs) in 2003, changing the entire pattern of funding and governance and the control was shifted from state to centre. Each of the NITs function autonomously sharing only the entrance tests between them. The autonomy in education enables the NITs to set up their own curriculum, thereby making it easier to adapt rapidly to the changes in industry requirements. Post upgradation, all the NITs have started showing great improvements in terms of student quality, administration structure, academic research, and student placements.

The reputation of NITs as centres of excellence has gained acceptance in industry as well as in academia, primarily because the standard of education and quality of NIT students has been consistently better than most other colleges in India. Various nationwide college surveys rate most of the NITs over other engineering colleges in India, except for the IITs and a few other institutions. NITs are again governed by a different act.

4.0 Polytechnic Education

Polytechnic represents a technical institution at the middle level which conducts full-time diploma courses in civil, mechanical and electrical engineering, etc.

After India got Independence in 1947, the Government recognised the importance of technical manpower for the economic development of the country and decided to expand facilities for technical education and technical training in a big way. In 1947, there were
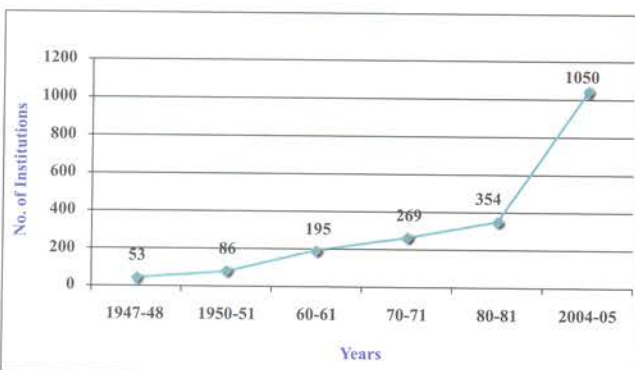
about 53 institutions conducting technician courses (diploma courses) with a total admission capacity of about 3,700 students per year; the total out-turn from these institutions was of the order of 1,500 per year. In 2008-09 the total number of polytechnics was approximately 1,300.

During late sixties, there was severe criticism of polytechnic education in the country. The Government of India constituted a Special Committee under the Chairmanship of Prof. G. R. Damodaran in 1970 to examine the entire system of polytechnic education and to recommend measures for improving the practical content of diploma courses through cooperation between polytechnics and industry. The committee's recommendations helped the Government to concentrate on qualitative improvement through starting of diversified courses and sandwich programmes, review of curriculum, inclusion of experts from industry, and granting of autonomy to polytechnics.

Some problems of the polytechnic systems are: (i) courses are theory-based and their practical content is inadequate, and (ii) polytechnic institutions can only give diplomas and cannot offer degree programmes like other universities. In India, in many states, the number of degree holders now exceeds the number of diploma holders. The trend needs to be reversed. Also, skill-based training needs to be imparted.

5.0 Role of Private financing in Technical Education in India

During the 1980s, there was unparalleled demand for skilled manpower and quality higher education relevant to the needs of business and industry. In 1986, Rajiv Gandhi announced a new education policy, the National Policy on Education (NPE), which was intended to prepare India for the 21st century. The new policy was intended to raise educational standards and increase access to education. At the same time, it was to safeguard the values of secularism, socialism and equality, which had been promoted since Independence.

Another very important development of the early 1990s that had tremendous impact on higher education was the introduction of new economic reform policies that included stabilisation and structural adjustment, which required a drastic cut in public expenditures in education. In fact, these policies set the tone for strong reforms in higher education in India in the following years and on the whole, higher education suffered severely. Public expenditure on higher education began to decline since the beginning of the 1990s.
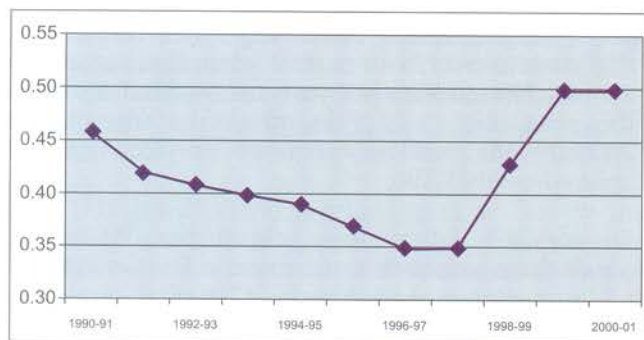

Fig 3: Growth of Polytechnic Institutions in India since 1947

Fig. 4: Declining Share of Higher Education in GNP (Per cent)
[Source: Tilak, Jandhyala B G, 2003]

The demand for technical education has grown far more rapidly than what public institutions can accommodate, and the Government finances were inadequate to meet the growing demand. With the initiation of the new economic reform policies, reducing budget for higher education, increasing purchasing capacity of middle class people, and the paradigm shift of Government towards primary and secondary education, a large number of private institutions and deemed universities came up, which led to imbalance in the quality of the technical education. Professional education expanded along with private education sector. Table 4 shows how engineering education has grown rapidly over the past 9-10 years.

Table 4: Growth of engineering colleges in India

Type	1947	1960	1970	1980	1990	2000	2006
Government and aided	42	111	135	142	164	202	212
Unaided	2	3	4	15	145	467	1299
Total	**44**	**114**	**139**	**157**	**309**	**669**	**1511**

The issue of private sector initiative in education sector has been a matter of great controversy and debate in India. According to the projection made by NASSCOM, the manpower requirement in IT enabled services alone was expected to grow rapidly to about 1 million by 2007 and by 2012 India is supposed to actually face a shortage of trained manpower in the sector. However, exhaustive manpower analysis needs to be done, for a follow up of this conclusion. Global recession has added to the confusion.

To meet the need of a much larger number of good institutions of engineering and technology, private initiative have an important role to provide opportunities for technical education to a much larger number of students, since this national need cannot be fulfilled by public funding alone. But the regulatory authorities like UGC and AICTE should try to ensure that this massive expansion does not dilute its efforts at supporting excellence and quality. Proper regulatory framework is needed for the private sector, in terms of their fees, admission process, teaching and learning process, and governance, to ensure the quality of higher education and also equity.

6.0 Curriculum & Quality Assurance in Technical Education

The core of technical education is the curriculum, which is not only need-specific but to some extent, also country/region-specific. Initially, the practical training for engineering education was imparted in factories – which later were transferred to laboratories and workshops. In India, AICTE has recently devised a new curriculum framework which includes the desired percentage of science, humanities, engineering science, core/professional subjects, design/project, laboratory, workshop class, etc. This is to allow cross-border movement of technologists and also for India being a provisional signatory of the Washington Accord.
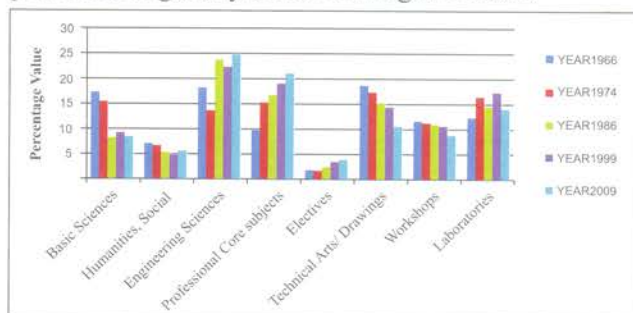

Fig. 5: Variation in the areas from the year 1966-2009 in the Mechanical Engineering curriculum.

A comparative analysis of the changing trends in the curriculum has been done for the mechanical engineering at first. The analysis shows the following patterns, which can be used for curriculum design in our country.

1.   The numbers of periods allotted to professional core subjects have witnessed a steady increase over the past 50 years as depicted by Figure 5. The percentage of periods allotted to this field has increased from 1966 to 2009. This significant increase has been necessitated due to developments in the field of mechanical engineering into newer areas of energy, manufacturing and interdisciplinary areas as robotics, biomechanics, etc. Also, more stress has been put on fluid machinery, manufacturing technology, and advanced computational techniques such as finite element methods. But this increase has been done at the cost of technical arts/engineering drawing, workshop classes.

2.   The contribution of technical arts/drawings to the mechanical engineering curriculum framework was 18.98%, as obtained from the 1966 period allotment. But this has seen a remarkable drop since then and has decreased to just 11.03% in 2009. This shows less emphasis on hands-on drawings over the period of time. The reason might be the perceived notion of lesser employment of students in consultancy organisations and advent of computerised drawing. The effect is yet to be observed because many of the engineering subjects, particularly engineering mechanics, need a very good conceptual understanding of the physical system which needs good concept of technical arts/drawings.

3.   Another significant change can be observed in the period allocation to workshops. The percentage of workshops held during 1966 has dropped steadily from 12.03% to 9.19% in the year 2009, a decrease of 2.84% (Figure 5). This strengthens the report by NASSCOM which says that 75% of engineers in India are unemployable, citing 'more thrust on academics and theory' as the reason. Engineering (or for that matter technology) relates to practical applications. So there is a contradiction here that needs to be resolved, even keeping in mind that the growth of the mechanical engineering discipline has been explosive.

4.   The percentage of elective period allocation has seen a steady rise from 2.14% in 1966 by 2.27% to 4.41% in 2009. This can be related to the point raised in the earlier conclusion that the students need to have core knowledge of the discipline. The specialised areas can be covered by electives (optional) which can be chosen by the student depending on his/her aptitude, as

well as the requirement at that point of time of the industry. It must be clearly noted here that the need of industry varies with time. To meet the outsourcing requirements of software management from some countries, engineering graduates were needed. But with the development of climate change issues and the thrust on biomedical solutions, the number of electives have been increased, as some of the following names suggest-solar energy, aerodynamics, computer aided design and manufacturing, biomechanics and biomaterials, advanced dynamics and vibration, design of thermal systems, etc.

5.   The percentage of humanities had decreased till the late 1990s from 7.45 in 1966 to 5.67 in 1986, but tends to show a gradual increase in the recent years from 5.34% in 1999 to 5.88% in 2009. World over, all the accrediting agencies are talking about the need of engineers having more communication skills, knowledge of economics, ideas of professional ethics, etc. So all the latest guidelines including ABET, Bologna, or India's AICTE suggest percentage increase in humanities courses. To incorporate this, some sacrifice may have to be made at other areas and that is yet to be agreed upon unanimously.

6.   The percentage of engineering science has not undergone drastic changes, although the data reveals an increase of 6.28% in recent years when compared with the 1966 index. This shows the trend has been towards increasing the percentage of engineering sciences in curriculum framework in order to instil in the student's mind a sound pedagogic system which aims at providing them with a clear concept of engineering at the beginning of the learning stage itself and strengthen their foundation to enhance their capability of understanding when they deal with professional core subjects and electives.

7.   Basic sciences are responsible for generating fundamental thinking ability in students. An analysis of the percentage of basic sciences over the years shows a steep decline from the year 1986 onwards. This remarkable drop is indicative of the fact that during the early 1970s the courses were based on a five-year duration which led to the introduction of calculus-based science subjects like physics, chemistry as well as mathematics to a much deeper extent than what they are in the present four-year curriculum.

Regular institute-industry interaction, which is critical to restructure the curriculum with the changing needs of the industry, is missing in India. Engineering institutions must interact and collaborate with the industries, for mutual benefit. Students benefit greatly from practical experience gained during summer job

or project work in industry – in terms of gaining practical knowledge. Engineering education faculty and administrators, and the programs that they offer, benefit greatly for guidance given by industry advisory groups. Industry also often provides direct support to engineering institutions, through funded research projects, equipment grants, sabbatical opportunities for faculty, etc. Industrial feedback is a must for any curriculum framework, which is absent in most of the education institutions in India. This has to be rectified and curriculum should be updated to meet the needs of the 21st century and make the students aware of local and global needs.

An analysis of curriculum of ranked institutions show that higher emphasis on engineering sciences and interdisciplinary subjects give rise to higher research output and better ranking in which our system is lacking.

In India, the AICTE has established National Board of Accreditation (NBA) in 1994 for quality assurance of technical institutions on the basis of guidelines, norms and standards laid down by it. Now, India being a signatory of the Washington Accord has to satisfy all of the following criteria for accrediting engineering programmes measured in terms of student outcome.

The program must have documented student outcomes that prepare graduates to attain the program educational objectives. Student outcomes are outcomes (a) through (k) plus any additional outcomes that may be articulated by the program.

(a) An ability to apply knowledge of mathematics, science, and engineering

(b) An ability to design and conduct experiments, as well as to analyse and interpret data

(c) An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability

(d) An ability to function on multidisciplinary teams

(e) An ability to identify, formulate, and solve engineering problems

(f) An understanding of professional and ethical responsibility

(g) An ability to communicate effectively

(h) A broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context

(i) A recognition of the need for, and an ability to engage in life-long learning

(j) A knowledge of contemporary issues

(k) An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

[Source:
ABET website http://www.abet.org/forms.shtml accessed on 16.03.11]

For such student outcomes, experienced and quality faculties are a must. Quality improvement programme for faculties need to be mandatory. In most countries in the world, the function of educational accreditation is conducted by a government organisation, such as a ministry of education. In the United States, however, the quality assurance process is independent of government and is performed by private membership associations. In India, the umbrella organisation is the NBA, which now has been made a registered society. In most of the countries the assistance of professional societies has been incorporated, but not in India. Quality assurance systems can be improved to raise technical education to world standard by strictly following a professional, transparent and nationally suitable model involving faculty members of the highest standard.

At present, the institutions cannot compete with the best unless they improve the quality of both teaching and research. They should initiate steps to increase enrolment at the post-graduate and research levels and to make strategic investment in research to have a comparative advantage in the global market.

References:

1. Agarwal Pawan; *Indian Higher Education: Envisioning the Future*, SAGE Publications, 2009.
2. Banerjee Rangan and Muley Vinayak P.; *Engineering Education in India*, Macmillan Publishers India Ltd., 2010.
3. Chandrakant L.S.; *Polytechnic Education in India*, D. B. Taraporevala Sons & Co. Pvt. Ltd. Bombay, 1971.
4. Fox Robert and Guagnini Anna(Eds); *Education, technology and industrial performance in Europe*, 1850-1939, Cambridge University Press, 1993.

5.   Ghosh Amitabha, Evolution of the IIT System & Excellence in Higher Education, *Reflections – IIT Kanpur*, Vol 8, No. 1, April 2007.

6.   Haggerty William J.; *Higher and Professional Education in India*, Washington, D.C., U.S. Department of Health Education and Welfare, 1969.

7.   Heywood John; *Engineering education: research and development in curriculum and instruction*, Wiley-Interscience, 2005.

8.   *International Journal of Engineering Education*, Vol.10, No.1, 1994.

9.   Kumar Deepak; *Science and the Raj – A Study of British India*, Oxford University Press, 2006.

10. Lux Donald G; Technical Education in India, *Comparative Education Review*, Vol. 7, No. 3, Feb. 1964, pp. 301-306.

11. Palit Sajal K ; The Development of Engineering and Technical Education in India, *Global Journal of Engineering Education*, Vol. 2, No. 3, 1998.

12. R Macleod and Kumar Deepak (ed.); *Technology and the Raj*, Sage publication, 1995.

13. Saha S.K.; Curriculum Design of Mechanical Engineering in a Developing Country, Proceedings of the ISEE 2010 – 3rd International Symposium for Engineering Education, Cork, Ireland, June 30 - July 2, 2010.

14. Saha S.K.; The origins of technical education in India: study of different approaches, Proceedings of the 4th International Conference of the European Society for the History of Science, November 18-20, 2010, Barcelona.

15. Sen S.N.; *Scientific and Technical Education in India 1781 – 1900*, INSA, New Delhi, 1991.

16. Tilak Jandhyala B G.; A decade of turmoil in higher education in India - Faulty assumptions, questionable approaches, and undesirable outcomes. NORRAG (Network for Policy Research Review and Advice on Education and Training) NEWS, Number 31 January 2003.

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