Transforming Engineering Education in India

K. Shenai[1], S. Bekal[2], K. Sankaran[3]

[1]Departement of Elecronics and Communication, N.M.A.M.Institute of Technology, Nitte-574110, Karnataka, India
[2]Department Mechanical Engineering, N.M.A.M. Institute of Technology, Nitte-574110, Karnataka, India
[3]Justice KS Hegde Institute of Management, Nitte-574110, Karnataka, India
[1]kshenai@nitte.edu.in
[2]sudeshbekal@nitte.edu.in
[3]sankaran@nitte.edu.in

Abstract: Since India gained her independence from the British colonial rule, education system in India in general, and particularly engineering education system, has not produced the kind of trained talent needed to develop and industrialize the country to be in par with the developed economies of the world. It is disheartening to see that Indian-born scientists and engineers who obtained their basic education in India have gone abroad and performed exceptionally well. The problem is deep-rooted as the Indian education system to a large extent suffers from age-old methodologies and beliefs that are cemented in the society. There is no reason why India cannot overcome this problem and unleash her enormous nascent human talent in order to rapidly develop and industrialize the country. Government deregulation and privatization, innovation and entrepreneurship, quality faculty with adequate compensation, and open-to-all competitive research funding are perhaps the key elements that may lay out the foundation for this transformation.

Keywords: Engineering, Education, Age-old Methodology, Government Deregulation, Quality Faculty, Competitive Research, Innovation, Competitive Research, and Industrialization.

1. Introduction

Industrialization of advanced economies in the world has much to owe to premiere educational institutions. For example, in the United States of America, Stanford University in Palo Alto, California, laid the foundation for Silicon Valley and likewise, Massachusetts Institute of Technology (MIT) in Cambridge, Massachusetts, largely provided the brain-power for north-eastern industrial corridor. Unfortunately, the same cannot be said about premiere educational institutions in India. Traditionally, large industries in India emanated from family-based entrepreneurial ventures whereas in western countries large companies were mostly built on innovative technologies from entrepreneurs educated in top universities.

India is the second most populous country in the world and has enormous human talent with nearly 65% of population under the age of 35 years. The challenge is to find most effective ways to convert this nascent talent into a productive enterprise that can rapidly transform India as a developed country. As shown in Figure 1, the educational system in India processes the raw human talent in multiple steps. At the K-12 grade level, medium of instruction is English as well as a number of regional languages. There is a huge amount of raw talent available at the K-12 grade level. However, due to financial considerations and severe competition, only a small percentage of this raw talent comes to engineering and science disciplines. Top students who want to study engineering prefer the elite IITs and NITs followed by a handful of private engineering institutions. In a given year this number may be roughly 50,000 students. Students have to perform well in a rigorous entrance examination in order to get admission in these good schools. Unlike in the 1960's and 1970's, students today undergo intense coaching classes to prepare for these entrance examinations. As a result, those who are successful in getting admission into top engineering schools may not necessarily be the best minds in the country.

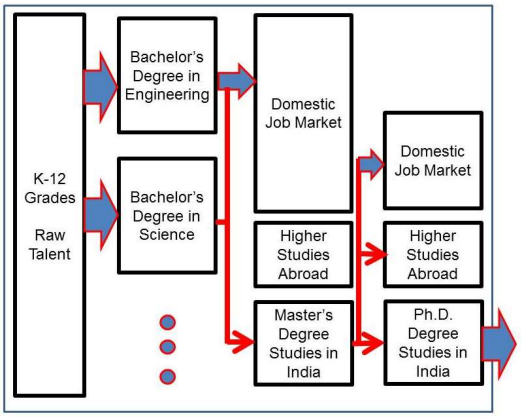

Fig. 1 Processing of nascent human talent in a typical Indian educational system.

K. Shenai
Distinguished Professor and Director (R&D), NMAM Institute of Technology, Nitte-574110, Karnataka, India
kshenai@nitte.edu.in

Most students who graduate from top engineering institutions in India end up getting lucrative job offers from multi-national corporations (MNCs) in India or abroad. A small percentage of good students prefer to go abroad for higher studies. Those students who prefer to pursue higher studies in India mostly prefer post graduate studies in other lucrative disciplines including management rather than in engineering. This preference in career goals by students can be largely attributed to family pressure caused by cultural and financial constraints. Today's situation in the country is in sharp contrast to what happened in the 1960's and 1970's when almost all graduates from top engineering institutions in India went abroad in pursuit of higher studies and in search of better living standards. The same expatriates contributed immensely in shaping high-technology industries and top research universities in their new found homelands. In the past, this flow of top trained talent from India to other countries was termed a "brain drain." Several good educational institutions in India including the IITs and IISc., were branded for producing such outstanding engineers. Unfortunately, the brain-drain today occurs mostly within India itself where the top students are not interested in pursuing higher studies in engineering but are lured away by other lucrative opportunities.

Most students who pursue post graduate degree studies in engineering in India today are those who could not find gainful employment or those who could not secure admission in foreign universities or top Indian management institutes. Although there are entrance tests, students who enrol in master's degree studies in engineering in India today are mostly sub-standard except may be at a few top-rated institutions. The quality of student pool available for doctoral studies gets further diluted as shown in Figure 1 for the same reasons described above. It is extremely difficult to attract top quality students to post graduate engineering programs in India because of inadequate financial incentives attached to a high-technology oriented career as well as other opportunities available for lucrative careers. Hence the development of India has seriously suffered. This situation will not change unless drastic measures are undertaken.

This paper is organized as follows. In Section II, data is provided on the current status of engineering education in India. Section III deals with government regulations and bureaucracy that are hindering or preventing improvements in the educational system. Section IV describes the specific measures that are needed to radically transform high-technology education in India so that the country can rapidly advance. The paper concludes with a summary of key observations and recommendations.

2. Current status of engineering education in India

Presently in India, higher education institutions mainly come under the bracket of government and private unaided categories as can be seen in Figure 2. The rapid rise in the number of private institutions is due to the inability of the government to raise funds for starting and maintaining institutions of its own. This is more so with engineering institutions where a large number of the institutions are run by private players. Before liberalization and during the period of licence-raj in India, a small number of job offerings, mostly in public sector units (PSUs) and small number of sick industries did not warrant requirement of engineers in big numbers. But onset of globalization and subsequent opening up of the market, necessitated

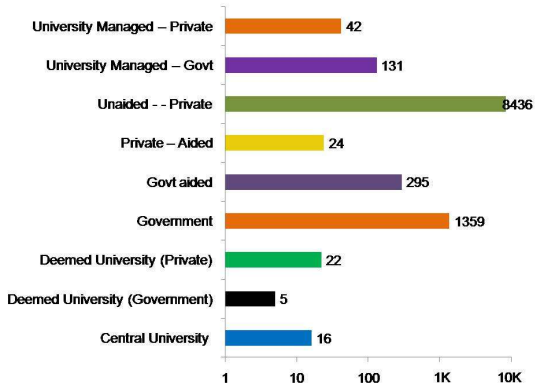

Fig.2 Comparison of number of institutions under various institution types in India(Source:AICTE,2016)

production of engineers in large numbers, which in turn led to the opening of large number of engineering colleges. What started as a trickle, soon turned into a glut, so much so that, colleges started finding it difficult to fill their seats once the information technology (IT) bubble had burst. With the urgent need to fill the seats in engineering colleges, the statutory body of the nation, lowered the eligibility criteria for admission into engineering colleges. Later, such students found it difficult to cope with rigours of engineering studies, necessitating the dilution of curriculum. As a result, most of the students found themselves unsuitable for employment on graduation, which led them to take up post graduate studies. These individuals, with poor foundation of knowledge, found it difficult to land a job in industry and hence, took up teaching as profession, resulting in further deterioration of engineering education.

Presently, there are about 6,432 engineering colleges and 3,479 management institutions in India which together constitute majority of the higher educational institutions as shown in Figure 3. Most of these institutions are privately managed. When the idea of allowing private players to start higher institutions was first proposed, people thought it was similar to liberalization and globalization happening in India. However, inability of the government to put in place proper checks and balances to ensure delivery of quality

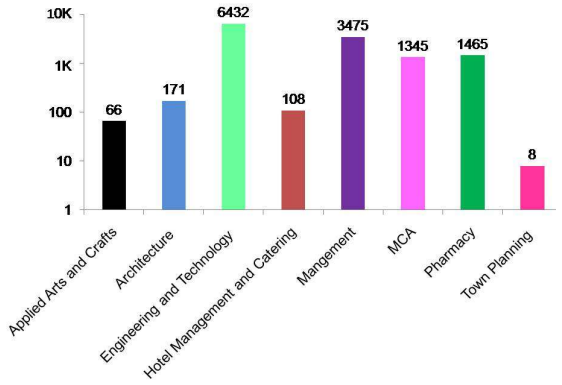

Fig. 3 Comparison of number of different types of institutions in India(Source:AICTE-2016)

education, profiteering motive of the institution, inability of the system to provide quality teachers, and attract talented people to teaching, have resulted in poor quality output from higher educational institutes. It must be mentioned here that the government of India did make efforts to improve the situation by introducing certain schemes such as research promotion scheme (RPS) of All India Council for Technical Education (AICTE) by way of which faculty members of engineering institutions were provided with funds to carry out research in their institution and improve themselves as well as improve the quality of students in their institution. This was also intended to create research culture in colleges. But such arrangements did not bear fruits to the expected extent mainly due to the focus of support being more on government run institutions. The proportion of fund given to private engineering colleges, which almost constitute 75% of the engineering institutes, is only 48% compared to 39% given to government engineering institutes, which constitute about 25% of the engineering institutes in India. This lopsidedness and absence of top quality research did not help the cause.

Additionally, there is a mismatch between increase in engineering colleges, and non-availability of qualified staff. India is producing about 1,300 engineering doctorates compared to about 9,000 in China and USA (Reddy and Kakodkar,2016). This has resulted in engineering teachers being either just post graduates, or still worse, in some cases, mere bachelor degree holders. If this is one face of the problem, the lack of infrastructure in large number of engineering institutions has resulted in poor exposure to practical/ laboratory work. Here again, the government support to self-financing institutions is lopsided. The share of modernization and removal of obsolescence (MODROB) scheme of government of India under AICTE was given to self-financing institutes, deemed universities, government institutes, and government polytechnics are 37%, 7%, 43%, 13%, respectively (AICTE,2012). Where there should have been larger share for private institutions, only 37% is given to them, while they form about 75% in terms of number.

To cut long story short, the poor education not only resulted in large drop out/ failures – 16% enrolment and 10% graduation - but, also caused poor quality graduates. Fortunately, the plethora of job opportunities provided by the IT sector could easily absorb the surfeit of engineers. This, however, partially resulted in low enrolment for engineering post graduate programmes and still lower enrolment for engineering doctorate degree seekers as shown in Figure 4, as compared to arts, commerce and science put together (MHRD,2015).

The B.E./B.Tech. students pursuing M.Tech./M.E. degree studies is about 4% which is lower than any other discipline as seen in Figure 5. To attract talented B.E. graduates to pursue a teaching career, AICTE had introduced "Early Faculty Induction Scheme" sometime back. Talented B.E. students were selected from a few institutions while they were in their final year and were paid a stipend Rs. 10,000 per month till their completion of the degree studies. Thereafter, they were sent to reputed institutions like IITs for pursuing their M.Tech., while being paid Rs.10,000 per month. The understanding was that, once they completed their post-graduation studies, they were expected to go back to their parent institution and render service as teachers. However, the programme did not take off as these youngsters with a degree from top notch colleges were able to gain employment in highly paid jobs in big companies. The poor salary structure at their parent institutions failed to attract them back.

With opportunities galore in industry for graduates from IITS/NITs and top students from other engineering colleges, the desire for pursuing post-graduate studies in India did not simply arise. With average salary for "campus-placed"

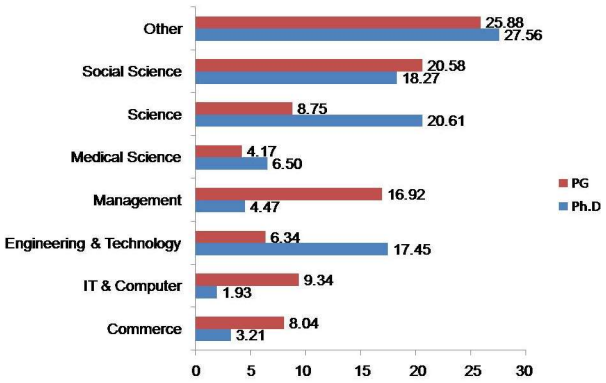

Fig. 4 Percentage enrolment in different disciplines for masters and doctorate degrees(Source:MHRD,2014)

students being Rs. 8 lakhs per annum at IITs, and Rs. 5-6 lakhs at NITs and other top notch colleges, the lowly stipend of Rs.12,500 per month paid for doing masters in Indian engineering institution was not enough motivation.

With only 5-10% of engineers produced by IITs and equivalent colleges and another 10% from autonomous institutions (Mohanty and Dash, 2009), there is an urgent need for increasing quality engineering institutions. It is also essential that top quality teachers make their way into these institutions so that quality of graduates coming out of these institutions will be able to make the country competitive. For this to happen, it is important to entice talented younger people graduating from top engineering institutions to take up post-graduate studies and later pursue research-oriented careers. This can happen only when engineering institutions are cured of certain ills namely, i) shortage of quality staff which is considered to be serious problem, ii) inadequate physical infrastructure and funds, iii) lack of autonomy, iv) rigid and out dated curriculum, v) poor quality of training, vi) absence of R&D activity, and vi) ineffective linkage with industry.

3. Governance and regulatory concerns

India has enormous nascent talent available for channelling towards post-graduate and doctoral level studies. However, the current higher education policies and regulatory systems have to undergo dramatic changes to generate a flow of capable, interested students from bachelors into masters and masters to doctoral programs in engineering.

If even after more than 60 years since the first IITs were established in India the situation is the same, there must be something wrong with the process of education itself. Advanced education in engineering requires a different approach from that at the undergraduate level. It is not any more about mass education. It is about generating an exciting and challenging environment that attracts potentially the best engineering talents of the country. For this to happen first we have to create the right processes within the educational institutions as well as its environment. The main aspect of the environment today is governance and the regulatory systems. The nature of the regulatory system under whose patronage most of the individual universities and institutions have to operate needs to be carefully examined.

Of course, the Indian engineering education system has independent institutions such as the IITs and the NITs which do not come under the purview of the regulatory bodies such as the University Grants Commission (UGC) and All India Council for Technical Education (AICTE). These institutions for various reasons have largely retained their preeminence only at the under-graduate level.

To generate excellent masters and doctoral programs we require an incoming student body that not only possesses adequate technical knowledge but also has the willingness to challenge existing paradigms. But the quality of people who seek admissions to these programs alone is not enough. The institutions themselves should be able to generate an environment where innovations and paradigm shifts are actively sought. When this is the case, it may be rightly stated that the existing policies followed by regulators are quite antithetical to excellence.

Current governance (or lack of it) and regulatory systems in higher education have led to:

- The maintenance of a subservience-oriented legacy system: The current university has its roots in Thomas Macaulay who brought in the affiliation-based "University of London" model. Unfortunately he did not bring in the University of Oxford or Cambridge models.
- Destruction of what should be trans-disciplinary universities to specialized ones: There are many engineering universities where students are not exposed to interdisciplinary studies. We even have universities for folklore studies! No disrespect meant to folklore. Just pointing out how universities are spawned to create advantages to those who create them. It seems that policy makers are incapable of imagining a university system where folklore and rocket science or music and geometry coexist in harmony!
- Perpetration of political appointments in leadership positions in the public universities.
- Spending huge tax payer money on government-funded central institutions that have largely remained "exclusivists": The leadership in these institutions are constantly called upon to spend their energy in protecting autonomy (and diabolically, exclusive privileges) rather than be supporting networks of institutions.
- Creation of research funding councils: This model is in consonance with Macaulay's philosophy of education. According to this, universities exist merely to teach (perpetrate the subservience model), not develop an intellectual class that can intellectually challenge existing unfair power structures or generate new knowledge.
- Licensing private institutions and having them work under syllabus and examination diktats that promote the status quo: Everyone thinks that license raj left the country in early1990s. This is not true of the education sector. Along with this is the continuance of institutions to control, equivalents of which have long

been dismantled in the UK from where the original models came.

- Creation of so-called quality systems like accreditation by multiple agencies (without clear idea why so many exist) that are poor copies from the West with least understanding of how they ought to work: For instance, the entire accreditation system in the US (and now adopted by UK) is based on self-regulation. Here in India it is based on bureaucratic controls set by the government-backed agencies.
- Creation of system where students are forced to be super competitive: This system has the students internalizing one single objective, viz., cracking the entrance examination. Much later in life they suffer the disjoint between their deeper interests and the jobs on hand. The end result is poor students.

It is noteworthy that the early IITs came into being during the 1950s. To keep these institutions away from the bureaucratic reach of UGC they were declared through acts of parliament as deemed universities with rights to offer their own degrees.

So despite the university system, the IITs came to be considered showpiece educational institutions in India in engineering. The lack of support for quality education under UGC and the emergence of IITs despite prevailing regulators were indeed reason enough for doing away with the bureaucracy of UGC. But this did not happen. This was a classic recipe for quick fixes. Instead of revamping the UGC and other institutions for affecting quality education they continued to exert major influence on other "lesser" programs and institutions considered inferior to IITs. These lesser programs included those offered by central universities (set up by the central government), state universities (set up by the state governments) and private universities.

The argument, reminiscent of India's caste system, was that IITs are and would continue to be special places with its select intelligentsia who can operate on their own while the lesser institutions, whether central or state or private, require the overview by a strong centralized regulator. The student intake based on IQ alone played as a gate keeper for admissions to the elite institutions. The rest of the engineering education was subjected to bureaucratic controls. The net result of the rigid structures has been very little opportunity for the agency (Mitra,2008) to exercise ground level judgments or affect innovations.

It is amply evident that autonomy of higher educational institutions is today closely related to the issue of ownership. Generally it is evident that where there is public ownership there is autonomy while in the private space there is no autonomy granted. This is a self-reinforcing situation. If the institution belongs to the private sector, there will be more controls and there is no way to introduce innovations and that consigns the private institutions to the second tier forever. India cannot afford to do this.

The report of India's National Knowledge Commission (NKC) advocates good governance in higher education rather than the prevalent system of controls being exercised by various agencies. It found that the prevailing system which is more regulatory in nature focuses only on punitive actions rather than on nurturing institutions. The power-based "inspection system" generally followed by the regulatory and accrediting agencies curb academic freedom of educational institutions. The ability of both institutions and individual scholars to pursue teaching and scholarship in a freethinking creative atmosphere is critical for the growth and nurturance of higher education institutions. Genuine self-organization supported by accreditation can actively protect academic freedoms while at the same time ensure that continuous improvement takes place. It is important to have the institutional missions remain at the heart of the process. The accreditation agency can ensure that accountability to various stakeholders is ensured by having institutions consult their stakeholders in defining and executing their missions. Serving diverse populations with the help of stated mission / vision would become a key starting point for evaluating the institutions for award of the accreditation status.

A report prepared by the American Council on Education (ACE) National Task Force on Institutional Accreditation in 2012 states that peer review forms an important component of accreditation. One of the key aspects here is peer review that relies on members of a professional community to examine practices rigorously based on professional norms. Peer review is the foundation of professional integrity and largely defines what it means to be professional. Unlike legislation or regulation, peer-based judgments can be applied flexibly and adjusted to local circumstances on the basis of shared expertise. Peer review also promotes the dissemination and exchange of best practices as faculty and administrators visit other institutions and provide advice designed to improve performance.

In India the so-called "peer review" by the accreditation agencies becomes an occasion for inspection and fault-finding rather than facilitating achievement of individual vision/mission and aspirations. Accreditation should protect the institutional autonomy and academic freedoms. It should also preserve institutional diversity while truly serving the constituents while setting in place accountability measures. The process of accreditation should be rigorously carried out by independent teams that subscribe to the principles of self-organization. Moreover, the standardization of accreditation principles should be at a sufficiently broad level. The nuts and bolts should be at a sufficiently "decentralized level" and should evolve on the basis of the requirement towards the attainment of the vision and mission of the individual organization.

4. Specific measures recommended

The overarching objective of any high-quality engineering education system is to produce top-notch trained engineers for the benefit of industries in the nation so that they can globally compete. As shown in Figure 6, engineering education system should be structured in such a way that the best nascent talent is channelled appropriately to rapidly industrialize the country to make India a global

manufacturing giant. A key goal must be to channel a substantial number of the top 25% of graduating engineers at each level to pursue higher degree engineering studies or to join high-technology manufacturing industries.

In order to accomplish this challenging objective, radically different measures need to be undertaken. These include, for example:

1. Reduce and/or completely eliminate federal control and regulations on all educational institutions;
2. Implement government policies and regulations that promote a competitive environment among educational institutions;
3. Implement government policies and regulations that encourage and promote top-notch private educational institutions;

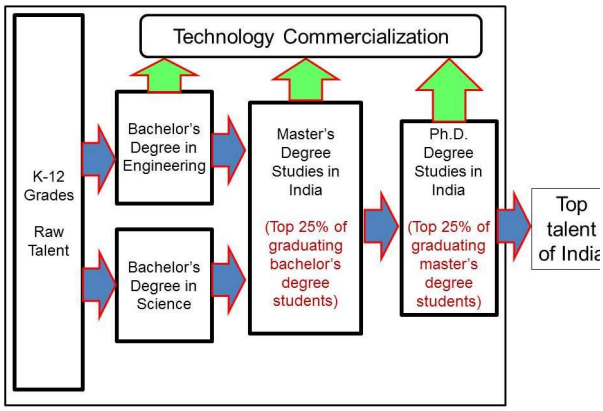

Fig. 6 A schematic structure of the proposed innovation-based high-technology education system.

4. Institute a credible single national accreditation body for evaluating and maintaining the quality of bachelor's degree education;
5. Integrate meaningful innovation and entrepreneurship schemes at all degree levels with tangible outcomes and appropriate commercialization outlets (NITI Aayog,2015);
6. Establish incentives for and promote Carnegie class of institutions of higher education in India;
7. Institute faculty tenure system in Carnegie class of institutions of higher education with an updated criteria for recruitment, retention and promotion;
8. Establish policies and procedures to ensure that all federal and state research funds are distributed on competitive basis open to all educational institutions;
9. Encourage and promote industry-university collaborative teams for conducting advanced product-oriented R&D projects with a commitment for technology commercialization within a stipulated time frame; and,
10. Establish meaningful guidelines on intellectual property related matters.

5. Summary and conclusions

In this paper, the current state of higher education and in particular engineering education in India is discussed. Although India has enormous nascent human talent, the current engineering education system is unable to adequately process and train this human capital for the betterment of society. Radical transformation of the education system is needed at various levels so as to channel the best human talent to the manufacturing industry so that India can emerge as a global manufacturing giant. The government has a major role to play, but not in the way it was implemented in post independent India. Private institutions need to take a significantly bigger responsibility in shaping the innovation-based education system.

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