Engineering Council of India

Round Table Conference

The Reform of Engineering Education- Contours of Reform

Background Discussion Note & Suggested Contours of Reform

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There is only one nature – the division into science and engineering is a human imposition, not a natural one. Bill Wulf:

If education is to serve the entire human being, the pursuit of knowledge will be a life-long process. Swami Vivekananda

Overview

The technical education determines the development and socio-economic condition of a nation. There is a greater need for high quality technical education to produce technically skilled workforce. Presently, India produces a little more than eight lakh engineers from around 3200 engineering institutions. But, MNCs find only 25 percent of these engineers employable (Mckinsey Global Institute Study & the U R Rao Committee study). This means that our engineering colleges are not producing employable engineers, of course there are exceptions that of IITs & NITs. This is the problem that we have.

The role of an engineer has undergone a major change with the paradigm shift from the traditional functional organizational structure to cross-functional organizational structure. Today, industry needs engineers who can perform a role of project engineers and managers. The current engineering education system does not produce such engineers. Some of the important reasons for this are: the present engineering discipline-based curriculum, which do not have subjects on economics, law, procurement and contracts, disputes & their resolution, finance, and communication, the method of delivery of the curricula, poor quality of the faculty, poor quality of infrastructure at a large number of engineering colleges, no project-based industrial training during-the-course, no internship with the industry after the course, no coordination mechanism in position of industry and academia, admission test for engineering courses does not assess the aptitude for engineering, etc, exceptions apart. Many subjects in the engineering curricula have become obsolete. We do not revise the curricula when it should be revised. There is not much motivation for research. Our Admin-regulatory mechanism of engineering education has not been delivering what it was supposed to do.

What is Ailing Our Engineering Education?

Specifically speaking, a vast majority of engineering students have no clue as to what a professional practising engineer does, and how interesting her/ his work can be. Industries bitterly complain about the lack of real 'understanding' by fresh engineers. In their hurry to meet semester deadlines, both teachers and students rush through the syllabus. One can imagine that it results in bad delivery of the course. The innovative thinking, creative thinking, thinking out of the box, lateral thinking, all evaporate in the process. Concepts of the subjects taught in this hurry bury of rushing through the syllabus, which is very important requirement under rules, get blurred. This is the problem. Then there is the other problem and this is that eengineers are taught by academicians who have no clue as to how do real-life engineers practice engineering; while as Doctors, Lawyers, Architects, Charter Accountants are taught by the practising professionals. Things have not changed during the last three decades. Some of the concepts that are being taught, topics and subjects that are in the curricula are quite outdated. There is too much of pure sciences and mathematics with no clear idea of their relevance to applications. While too much theory is taught, too little emphasis is given on experiments and on- the - job training. There is no solid interdisciplinary base. There is too much of the

compartmentalization. Students have no idea as to what they are studying and what they are going to do. Technology today has become more interdisciplinary. There is no subject that can make you understand technology in its entirety; it needs interdisciplinary knowledge and skills to understand and comprehend. We do not attract competent people to the faculty work which is generally attributed to poor pay scales, lack of incentives and lack of glamour to work as a faculty to teach engineering.

It is generally perceived that teaching and training procedures and practices being still followed by the engineering institutions have also become obsolete, a few exceptions apart. The teaching should not remain confined to the classrooms only, as is the case generally at present. In order to be able to correctly visualize what is needed by the industry, the teachers must be more than competent. If the product from education sector is required to emerge as robust, the academic process must be strengthened for its design-abilities. Generally speaking, engineering faculty does not interact with the industry here in India. In developed countries, by & large, the institutions teaching engineering remain in touch with the industry for various things including for providing consultancy to the industry for solving their problems. There is no such practice here in India, some exceptions apart.

The current engineering education system focuses on learning by rote; education should create thinking minds. "Of all the big issues challenging corporates, education is the starting point. Institutions generally do not have training capabilities in new areas of job growth as globalization, deregulation and competition change expectations of employees faster than teaching institutions do. Fresh engineers do not have sufficient knowledge & skills to start working straight away on their jobs in an industrial unit. They need retraining which means expenditure that the industry will have to bear. We have also working engineers who often get stuck in the domain-specific jobs. They do not move out to acquire multi-skills required today for meeting the changing needs of the engineering profession. Too much theory is taught; too little emphasis is given on experiments and on- the - job training. There is, therefore, no correlation in the present engineering education system between theory and practice. Our current engineering education system does not prepare engineers for the industry because it demands engineer managers to manage mega projects of integrated technologies.

The Indian engineering education is totally focused on a “career excellence”. A student is never asked to analyze, understand, and deliver an engineering project. Very often faculty also has no engineering experience. Professors may have an excellent academic background acquired through graduation, post graduation and PhD, but this is all with a minimal exposure to industrial applications. They prepare their students also for an excellent academic career expecting her/him to learn hard core engineering on the job but very often producing bankers.

In all there is about three months spent in training during graduation. It is taken more as a break from courses as no industry will give any serious project for such a short period. Students spend their time as observers rather than as responsible engineers. There is nothing like putting a trainer on a real job under the supervision of an experienced engineer. By the time, s/he has finished six months to a year working on a real project, as any European student does, s/he will have something to her/his credit to show to a future employer.

Illustratively, presently, only civil engineers, by and large, are in demand from the construction sector. A civil engineer is not a **construction engineer** by virtue of her/ his education & training as such..A construction engineer needs a familiarity with the world of business and commerce, dealing with people and resources, environmental, health and safety aspects, legal aspects, project engineering, logistics engineering, procurement engineering, application of IT and communication technology

in construction, dealing with partnerships and joint ventures, learning the nitty gritties of contracts and claims, apart from the changing world of technology itself. Therefore, a construction engineer should be far more multi - functional and better equipped to deal with complex issues of construction business than say, a pure civil engineer can do (Dr.P.R.Swarup, DG, Construction Industry Development Council). It means, therefore, that a construction engineer is much more of an engineer - manager. So, there is a case for a new branch of construction engineering.

We still dependent on foreign expertise for technologies and projects, or, for modernization of the existing operations, with some minor exceptions of course being there. There is not much motivation for research. We also lack in research infrastructure. We produce much less numbers of quality PhDs in engineering when compared with China , the US, the UK and other developed countries. . So we lack in quality researchers. Of the large number of engineering institutions in the country, most are hardly involved in research. This does not auger well for the country's future. Research is symbiotic with teaching. Research in science and engineering must be encouraged; just twenty or thirty such institutions are not enough. Given India's population size, there should be at least a hundred of them.

Funds for Higher Technical Eeducation

Higher technical education in India is perceived to have been a victim of lack of finances for many years since independence. According to the National Institute of Educational Planning and Administration, the share of government expenditure on technical education is presently around 4 percent. In China, the amount spent on research and development, especially in engineering fields, is a good 10 percent. The present dismal state-spending on research and development is also an important factor for the problem that we are facing. The question, therefore, arises: how can we solve the problem of financial crunch to overcome the related problem of faculty crunch in leading engineering institutes/universities? A comparison of' salaries in the corporate world with those in academia explains why increasingly large numbers of bright students opt for a career in the private sector instead of entering academia. The best minds are not coming to the field of teaching as this profession is not yet considered to be attractive enough in terms of salary. Consider, for example, the salaries of the teachers in Indian universities. Despite the quite large increase in salaries after the last pay commission report, university salaries in Indian remain grossly inadequate compared to remunerations available elsewhere.

Reform of Engineering Education System – a way Forward

Engineering involves men, materials, machines and energy. Engineering requires the creative imagination to innovate useful applications of the natural phenomena. Creativity or innovation in engineers is, therefore, the need of the day. Engineers are required to optimize on using natural sources of energy and materials to meet the growing competition. It will be possible only with multidisciplinary engineers. The engineering education system, therefore, needs to move out of its present engineering discipline-specific engineering system to multidisciplinary education system. This will mean reforming engineering education system. But, we need to do it with caution, taking short-term measures first and then going for long-term measures. In the short-term, we should revert back to previous practice of having two years of common curricula and allotting branch after the third year. Then we should reform the curricula itself and remove subjects from it which have become obsolete, and add to it subjects such as economics & statistics, subjects from the management science such as project management, communication, production management, managerial economics, finance, and marketing of engineering products, international marketing; and then subjects such as law, disaster management, English language and subjects dealing with various statutory

bodies, etc. The learning pedagogy should be modified to place more emphasis on self-learning and problem-solving. We should create a coordination mechanism of academia and the industry that could drive curriculum reviews, upgrades, and staff training at regular frequency and align the programme for matching the knowledge & skills of engineers to the requirement of existing and anticipated technology - intended to be installed by the industry. This might give a better return on investment on skill development. The state-of-the-art technology needs to be adopted for delivering the curricula. Inter-institute credit transfer should be permitted. The entrance examination for engineering course should also assess the aptitude for engineering; and there should be one common entrance examination for admission to engineering courses at the national level. The states need to be brought on board for this purpose. Fresh graduates lack a strong ethical foundation. Introduction of ethics as a subject in engineering education should be given a serious consideration.

The **diploma engineering education** can continue o be in the engineering discipline format as at present with a bit of re engineering done, particularly for improving the English language and communication skills of the students. Since the diploma engineers normally perform also a supervisory role in the industry, it will be desirable to introduce the basics from the management science and economics to the curricula. The quality of infrastructure and that of the faculty of our polytechniques should also be upgraded, as required.

We also need to train **engineer technicians** for meeting the rising demand for the various vocational skills from the industry as well as for catering to the demand from the other countries for these vocational skills keeping in view the fact that there is a net shortage of these skills abroad, particularly in the developed countries. This is because of ageing population in these countries compared to India. This demographic dividend that India has can be cashed by supplying very well trained diploma engineers and engineer technicians who have not only a very good knowledge of their engineering subjects and trades, but they are also articulate and have English language and communication skills, apart from a very good general knowledge.

Industrial Training

The industrial training during-the-course should be project-based and mandatory. After the course we should introduce a six months – to- one year paid internship with an industrial unit. As a matter of policy, it should also be made mandatory. Both these trainings should be assessed and credits added to the marks obtained by a student from the written examination and internal assignments undertaken during the course. The final engineering degree should be awarded only after all these assessments have been completed. However, after clearing the written examination, a provisional degree can be given. The industry should be involved in this; and it should also be compensated for the expenditure that it may incur on this training via the tax route.

Curriculum Design

A modular approach to curriculum design could go a long way in optimizing the entire approach to curriculum design. We could conceptualize the entire undergraduate curriculum to comprise of distinct modules – vis - a - vis courses which is the basis as of now. Each module can comprise a set of course(s) which can seamlessly fit into the larger design of the programme. A programme, say of Bachelor in Mechanical Engineering could comprise of modules drawn from areas such as basics of other major branches of engineering during the first two years of the course and then mechanical engineering subjects and other value adding modules from areas like economics, soft skills, management, legal aspects and so on during the remaining two years of the course. But before it is done, we should weed out the courses gone

obsolete from both these streams. Many of these modules could be of generic type and could be replicated seamlessly across a range of other programmes.

Curriculum Delivery

In curriculum delivery, a similar modular approach could be pursued. Thus, one could start with modules on generic engineering, moving on to discipline - based engineering, then value adding modules. Evaluation and assessment could be module - based instead of year - based as is the case at present. The role innovations in curriculum delivery play in effectiveness of education at higher levels. For instance pedagogical methods such as case method, role plays, simulation, games, live projects, etc, have revolutionized the curriculum delivery systems and established their primacy in higher education.

Faculty

India needs quality academicians to mentor engineering students and researchers in right direction. Academicians should make a temporary transition to the world of work from the world of teaching. They should be involved in industrial environment. In the Indian context, theory and practice are totally divorced; and that is why, it is necessary that practising engineers & eminent engineer consultants (the practitioners in the industry) are also involved in teaching engineers. Members of the engineering faculty should give up its arrogant know-all attitude about engineering; and be consistently open and learn state-of-the-art developments from practicing engineers & engineer consultants. This is a normal practice in the developed world. For this we need an effective and efficient industry-academia working coordination mechanism. It will not only improve the quality of education and research, but also fulfil the need for the adjustment of training to the prerequisites of employment at the work-place. Practising engineers & eminent engineer consultants should also be in drafting and detailing of the curricula. Reiteratively, engineering curriculum should also include case studies on real life problems. Practising engineers can better teach this subject. The faculty for this should, therefore, be of practising engineers from the industry and eminent engineer consultants. Members of engineering faculty do not have any experience on why & how the industry works. For acquiring this experience, they should make a temporary transition to the world of work from the world of teaching. Traditionally, members of the engineering faculty have been discouraged from industrial consultancy in India. This is not the case in the developed countries. We should create a mechanism for facilitating the exchange of members of the engineering faculty for short periods to work in the industry and practising engineers & eminent engineering consultants to teach engineering. This exchange will provide an opportunity to them to have a hands-on experience of the "other side of the fence". *It should be, therefore, made mandatory that members of the engineering faculty work in the industry for a minimum period of two years after every five-to-six years in their total service period. Like-wise it should be made mandatory for practising engineers & eminent engineer consultants, who also want to teach engineering, to work on the faculty for a similar duration in their total service period.* This exchange will go a long way in imparting much needed practicality to our engineering education system. Equally important it is to train members of the engineering faculty in the field for overcoming their rigidity about the curricula. Then only one can think of having excellent engineers, industrial leaders, researchers, designers and technologists.

The number of engineering faculty, many of whom fall short of the required quality and qualification, may be as high as one lakh. There is, therefore, an essential need for an aggressive quality improvement programme. Short term training programmes and employing other faculty development programmes would help in significantly improving the situation. We should also develop an effective & efficient institutional mechanism for continuing professional

development for members of engineering faculty. It should also be made mandatory that they should continue keeping themselves up dated, which should also be monitored. Some disincentives should be built into this mechanism for not meeting this requirement.

For meeting the shortage of quality faculty for teaching engineering we should make teaching positions attractive by maintaining near parity with the jobs in the IT sector. This is very essential for improving the situation. Second, as stated above, we should involve practising engineers & eminent engineer consultants to teach engineering. The institutions need to increase the amount of money spent on faculty to lure the best talent.

It should be reimbursed that only teaching (without any productive research in the form of quality publications or usable patents) does not justify huge spending by some so-called 'elite' institutes / universities. Instead, based on some quality criteria, all institutes / universities should be graded and judged as per their performance and the public monetary support should depend on that. Performers should be separated from the non-performers and the performers should be given more incentives. Performing institutions should be given more financial grants as an encouragement for better quality teaching and research.

Design Engineers

India, as a nation, is very weak in designs. Engineers should have skills to use mathematics and science to design new artifacts and technologies that may be used to solve practical problems. Without having the capability for designs, we cannot lead as a nation. Importing machines or technology always does not work in Indian environs. More respect for original indigenous resourcefulness needs to be inculcated. Made in India' (designed and perfected in India) need not be an apology. If imports are a must in some new-fangled disciplines, greater transparency needs to be assured. Here also there are commonalities and synergies among all the major branches of engineering, which need to be harnessed appropriately for making a design to tick (Prof. Max Babi).

Economics for Engineers

All engineering activities have economic implications. Without the knowledge of economics, engineers will be unable to accomplish the economic part of engineering application in an effective way. The success lies in applying their knowledge of physical sciences with judgment to develop ways to utilize available resources to yield maximum returns for human beings. This empowers engineering students to make well-reasoned decisions-in analyzing personal decisions as well as business, technology and informed conclusions about public policy based on a comprehensive analysis of costs and benefits of alternatives. Hence, it is necessary for engineers to be trained in the analysis of the economic aspects of engineering applications. Economics is not included as a core subject in engineering curriculum, exceptions here and there apart. Though the AICTE has issued guidelines regarding this, these guide lines are not being followed. These guidelines should be followed by all the institutions.

Long-Term Reform of Engineering Education System

It has been recognized by all the stakeholders that in the long-term India should move out of the present engineering discipline-wise engineering education to multidisciplinary engineering education at the undergraduate level. We should , therefore, look at engineering education from the user driven perspective, which implies that the focus towards users calls for the engineering education system to be far more multi disciplinary, multi functional and, therefore, more seamless than has been the case so far. We, therefore, need to create engineering branches at the undergraduate level which will meet the unique needs of the economic sectors such as civil aviation, ports and harbours, urban renewal, manufacturing, logistics and

transportation, telecom and power, oil and gas, and various other areas of infrastructure wherever investments and execution of projects on a large scale is paramount**.** All these sectors need multidisciplinary engineers with management skills and also a fair amount of knowledge of law, economics, statistics, communications skills, etc. The new branches could be Bachelors of Infrastructure Engineering, Bachelors of Manufacturing Engineering, Bachelor of Construction Engineering, Bachelor of Hydrocarbon Engineering, Bachelors of Engineering & Management of five years duration, and a general branch of Bachelor of Engineering. Postgraduate engineering education should be on specialized subject basis.

Illustratively, a shift towards general engineering has happened at various educational institutions in the world. Some US universities have started bringing in goals such as excellence, quality, relevance, customer satisfaction, and service mentality into the curriculum. Various universities in the US offer seamless programmes s in engineering, which confer **B. S. Degrees in Engineering,** without assigning a branch. As part of the educational curriculum, these programmes also help students to participate in internship programmes, which produce better employment opportunities. The graduates with a general engineering degree have broad knowledge which makes them suitable candidates for most of the careers. The University of Illinois in US has a department of general engineering. They have now developed a department of industrial and enterprise systems engineering, which imparts education in combined systems and business education, which is one step ahead of the seamless engineering education policy. Reportedly, some IITs in India present a practical scenario where seamless engineering education has been practiced in a limited and judicious way, appropriate to the requirements of the nation. However, a lot of modifications in the system, and refinement of strategies are still possible. We should look at these. We, as has been stated earlier in this note, need to create a new branch of **BE (Construction Engineering)** for meeting the growing demand of the construction industry. As a matter of fact some universities in India are considering creating this new branch of engineering In sum: we should create sector – specific new branches in engineering as a matter of long-term measure to be taken on the reform of engineering education system.

Other Issues Related to the Reform of Engineering Education System

Professional Engineering Diploma

There is a need for introducing special level courses for serving engineers which could be termed as a professional engineering programme leading to a diploma in P.E. (Professional Engineering). The curriculum could be drawn, discussed and agreed to, which should be based on a consensus of academics and industry and practising engineers.

Technical Books

All technical books contain theoretical problems. There is hardly any book which really talks of real-life technical problems. Technical books should be there on real life case studies from the industry.

Industry-Academia Interactive Mechanism

Reiteratively, the Industry must play the proper role in the area of engineering education. The professors must teach what the industry wants. The industry must, therefore, take the initiative in deciding the framework of the syllabi of engineering courses with a view to delivering the proper output. The practical conditions in which the students will be working after passing out must be taken into consideration. Today, there is no collaboration, no interaction, no interface between the engineering educational establishment and the industry. So, the out put from these establishments is not what the industry needs. We need, therefore, a collaborative education system with the industry. Unless there is this collaboration between

engineering educational establishment and the industry, we will not get a required quality out put of engineers from these establishments (Prof Raja Kumar, IIT, Khargpur).

More so, engineering education would have to be based on the consensus of academics, industry and practising engineers. There should be, therefore, a synergy between the industry & academia on a regular basis which calls for integration of industry & academia at all levels such as for revision of teaching methodology, syllabi, exchange of faculty, technology transfer, etc. We need to have, therefore, an active interaction with the teaching institutions and the industry with a view to imparting the required skills to engineering students. We need to create such a mechanism at the national level for enabling continuous interaction of the academic institutions with the industry at the domestic as well as international levels which will make it possible to get the right kind of quality technical education in India for making her a global leader in the field of technology and engineering workforce.

The Quality System

We need to establish a datum for measuring the quality and excellence. The accreditation factors should be the quality of teaching, level of research, and faculty expertise. While many engineers join the faculty, they, at the same time, keep on looking for well paid jobs elsewhere and when they get these jobs, they quit the faculty and that too many a time when they are ready to be groomed up for being a very good faculty. This is the problem that we should tackle.

We should also create an evaluation mechanism for assessing the quality of the faculty; and it must be done periodically. Finally, we should set standards for the infrastructure and the accreditation should be given to the new institutions in the business of engineering education only if they meet these standards fully. Like-wise the present institutions not meeting these standards of infrastructure should be directed to up-grade it to these standards in a given time-frame; if they do not do it, their accreditation should be withdrawn. There should be no compromise in this, as we can no longer afford compromising on this matter now. This should be very clear. Bodies like AICTE and UGC should ensure all this.

The advent of nanotechnology can lead to a major re-engineering paradigm shift. It involves manipulation at the molecular or nano-particles. The finished product based on this approach is of far superior quality and there is minimum wastage of the raw materials as well as energy. It would be wise for different Indian organizations to introduce emergent technologies courses consisting of almost fifty percent of nanotechnology; while also covering some other areas as well. Our engineering colleges need to take the initiative in developing these needed courses. The existing engineering workforce needs to be trained for the optimum utilization of the new technologies.

The administrative set-up for higher technical education in the country needs a through revamping and made more flexible and purposeful. The government should try to integrate its own administrative set-up for managing higher technical education. There is a need to bring in seamless or single window administrative institutional set-up for managing higher technical education, which will go a long way in improving our higher technical education in the country.

Washington Accord (WA)

There are various international agreements including the WA which mutually recognize engineering degrees of its member countries. India is a provisional member of the WA. Our engineering degrees are, therefore, not recognized by other countries. India should become a permanent member of the WA and the other similar world bodies without further delay for enabling to get recognition abroad of our engineering degrees which will facilitate our entry to the world market of engineering services.

National Proficiency Evaluation Test for Graduate Engineers

We do not have any institutional mechanism for measuring the proficiency of engineers that we produce. We need to test the professional competence of engineers who pass out every year from our engineering colleges for their employment in the industry and in the R&D establishments, For this we need to put them through the proficiency evaluation test (NPET) soon after they pass their engineering course. This will also help not only in the selection of the proficient engineers for the industrial & R&D jobs, but also in providing (a) feedback to the academic institutions across the country on the quality of their education for its improvement, as required, (b) taking critical decisions regarding the process of hiring in the professional field, and (c) providing guidance on updating the various training programmes on a national base. We , therefore, need to have in position at the national level a proficiency evaluation test for graduate engineers. Engineering Council of India is seized of this matter and some actions have been taken to create a working mechanism for the NPET in the country.

Academic Board

AICTE should have an "Academic Board", comprising members from the academia, industry, research institutions, and eminent engineer consultants. This board should review curriculum, make it more practical oriented, oversee internship programs for students, identify/create "Visiting Faculties" from the industry/research institutions/renowned technocrats, select practical projects for thesis necessitating participation of the industry, motivate the industry to sponsor projects/programs, identify/nurture researchers, designers, and innovators, and set-up design institutes/departments.

A Legal Status for Engineering Profession

Presently, engineering profession has no legal status as such in the country because of there being no Engineers Act on our statute, unlike other professions such as Lawyers, Doctors, Architects, Accountants, etc. There is a great need for this.

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Suggested Contours of Reform of the Engineering Education System & Policy Issues Thereof

Consensus recommendations of the seven national conventions, two national conferences and a national workshop on the reform of engineering education system for better employability of engineers and related themes organized by the Engineering Council of India during 2006-12 at different places in the country, which were all very well attended by both the academia and the industry, are given point-wise below. In essence, these are suggested contours of reform and will also come up for discussion at the Roundtable Conference.

1. India should become a leader of engineering knowledge economy through enhancing the standards of its engineering education system

2. Needs of an economy & society are ever changing. Hence, the Indian economy today demands multidisciplinary & multi-skilled engineers. Such engineers would have to be produced in the country. Therefore, engineering education system of old functional paradigm needs to be looked from the "user driven "rather than a ' discipline perspective-as is the case at present"

3. Eengineering education needs, therefore, to be moved out of its present branch - specific engineering education to multi-disciplinary engineering education and made more practical. It should be done not in one-go, but with caution and in steps

4. The quality of engineering curriculum should be made compatible with the requirement of the industry; and it should provide a greater flexibility and choice of electives

5. The curriculum for engineering education should, therefore, be based on the consensus of academics, industry and practising engineers

6. We should revert back to the earlier curriculum of having common subjects during the first two years of the course; and the branch should be given in the third year of the course after evaluating the performance of a student during the first two years of the course. This should be done universally in all engineering branches

7. The subjects gone obsolete should be removed from the curriculum of all branches

8. The subjects from the social sciences-economics, statistics, management, communication, law, etc. should be added to the curriculum

9. Other soft skills such as etiquette, table manners, inter personnel behaviour, etc, should be developed in the students at the college level itself.

10. *The periodic review of engineering curricula should be made mandatory. The periodicity for this could be every four or five years; and it should be done in consultation with the academics, industry, practicing engineers and eminent engineer consultants*

11. Computer simulations should also be used for laboratory practices. It will make it very easy for the students to understand various concepts

12. *Reform of the engineering education system should also include reform of the present common entrance test for admission of students to engineering courses for ensuring*

the selection of only those candidates who have not only the knowledge of physics, chemistry, mathematics and general knowledge but also aptitude for engineering.

13. *There should be one all India common test for admission to engineering institutions. Engineering establishments in the private sector and those of the various state governments should also accept this all India common entrance test for admission to their establishments.*

14. *For producing engineers of knowledge and skills that the industry needs, there is a need to make the engineering syllabi at the undergraduate level multidisciplinary, and therefore, engineering education should eventually move out to become multidisciplinary, but this should be done with caution and taking step-by-step approach by introducing first a few new branches such as BE (Construction Engineering), BE (Hydrocarbon Engineering), BE (General Engineering) and a combined five-year degree course in engineering & management.*

15. *We can also think of an option of introducing general engineering course of four years as: two years of the course and then joining work with an industrial unit for one-to-three - years and then returning back to the course for the next two years to complete it.*

16. *The combined degree of engineering & management can also be split in two streams as: first three years in a college and then two or three years of work with an industrial unit and then two more years in the college for completing the course*

17. *For making available right engineers to the Industry for their applied R&D, the postgraduate engineering degree can be of five years comprising a general engineering course of four years and specialization of one year after that*

18. Alternately, it could be a general engineering course of three years and two years of specialization thereafter- either in continuity or with a break of two years which can be spent in an industrial unit

19. Alternatively, it could be a two - years of postgraduate course in engineering in continuity of four years of general engineering course at the undergraduate level with a break of two - to -three years for taking up employment in an industrial unit for gaining experience of the industry (Via this mode, we will produce engineers for teaching engineering & for the R&D sector after students also obtain a PhD degree)

20. Acquisition of additional skills concerning the core professional values such as creativity, clean environmental sustainability-cum-development, societal benefits, etc. is essential for all professionals before they can start practising their profession

21. Engineering students should be given increasing responsibility for taking charge of their own studies and the engineering courses should be open-ended, constructive, inventive and investigative coupled with assignment-work involving groups of students

22. Development of communication skills in engineering students/engineers should be attached topmost priority, as their workplace demands it more importantly over high level of mathematics and, likewise, group working skills assumes priority over academic individuality

23. We need to harness appropriately commonalities and synergies among all the major branches of engineering for developing designing skills in engineers

24. Recognized that the fresh engineering graduates lack a strong ethical foundation, introduction of ethics as a subject in engineering education in universities needs a serious consideration

25. The practical case studies need to be included in the technical books and other reference materials meant for engineering students

26. Disaster management needs to be incorporated in the engineering curricula

27. Emphasis should be on practical engineering education which should also include sustainability aspects by introducing in the curricula a compulsory subject on sustainability which may include the philosophy, the basic and general concepts of sustainability and its practical application

28. For the multidisciplinary curriculum of engineering education, the weights to be assigned to different subjects as humanities, social sciences**,** basic sciences, mathematics, engineering core subjects, elective subjects, etc, should be decided on a consensus basis of the academics, the industry, practicing engineers and eminent engineer consultants

29. *It should be made mandatory to upgrade engineering curricula once in every four years keeping in view the changes in the perspective of industry, R&D, etc.*

30. *As per the Washington Accord, regulatory mechanism should make it possible to transfer credits between universities / Institutions in the engineering degree programmes*

31. Though quality improvement programmes for teachers have been reportedly set in motion, results are not yet spectacular. This issue needs to be tackled so that we get quality faculty for engineering education

32. *.Industrial training for the faculty should be made mandatory. For this, the industry should spend a part of their income to train the faculty and student and it should be compensated via tax incentives for any expenditure that it may incur on this training*

33. E-learning and web- based teaching methods need to be introduced

34. The faculty should give up its arrogant know-all attitude about engineering and be consistently open and learn state-of-the-art developments from practicing engineers

35. *Practising engineers and eminent engineer-consultants should also be involved in teaching for bring a very rich experience in teaching and setting syllabus and they will not be competitors of the main faculty*

36. *Industry - Academia partnership in technical education should be institutionalized for revision of the curricula & its delivery, exchange of faculty, etc*

37. *The industrial training during the second, third & the fourth year of the course* **s***hould be in the format of small projects on industrial problems assigned individually or collectively to a group of students, It should also be assessed and marks obtained thereof should be included in the marks obtained from the written examination, and it should be made mandatory*

38. *After the theoretical course and during – the-course training is over, there should be a mandatory six months- to - one year of paid internship with an industrial unit which should be assessed and credits thus obtained by a student should be added to her / his total credit and the industry should be compensated or any expenditure that it may incur on this internship* via *the tax route*

39. *It should be made mandatory that a student will get the final engineering degree only after successfully completing during – the - course training and after- the – course paid internship of six months-to- one year with an*

industrial unit, after clearing the written examination, however, a provisional engineering degree can be given

40. The practice of delivery of engineering education should be reformed from its present form by placing more emphasis on self-learning and problem-solving

41. *Exchange of professionals for short periods between the academic institutions and the industry should be made mandatory for providing an opportunity to them to have a hands-on experience of the "other side of the fence"*

42. *Evaluation of the faculty by the students should be made mandatory for all the engineering colleges in the country*

43. *A working mechanism needs to be created and operated as a matter of regulatory policy on collaboration with the world class foreign universities for the faculty exchange and establishing of research centres, apart from developing modern curricula*

44. *The associate membership certificates awarded by the various professional engineering associations / societies/ institutions should be arranged to be recognized by some university so that persons having these certificates become equal in academic sense with that of a degree holder in engineering from a recognized university*

45. *Engineering profession needs also to be regulated like the other professions such as Lawyers, Doctors, Architects, Accountants, etc are for giving a legal status to engineering profession and ensuring accountability of engineers to their decisions*

46. The continuing professional development (CPD) should form an important element of the regulatory mechanism of engineering education

47. The culture of accountability leading to the culture of sincerity in the profession must be infused in the engineering institutions.

48. *The foreign direct investment (FDI) for engineering education system should be encouraged with a view to bringing in competition vis-a-vis indigenous institutions for enhancing the standards of education*

49. *The merit should not be compromised for the quotas for admission to engineering colleges*

50. *The vocational engineering education system at the workers level needs to be upgraded and made as an option of 10+2 education, particularly for the students of rural India and the ITI- based education for engineer technicians should be made a part of this process*

51. *The curricula and training format of the polytechnics and industrial training Institutes (ITIs) training diploma engineers and engineer technicians respectively need to be re-engineered for imparting required knowledge and skills to diploma engineers and engineer technicians*

52. *The English language skills of diploma & engineer technician students also need to be made better by including the language in their curriculum*

53. *The synergy in the various efforts that are being made by the various agencies in training the technical workforce in the country needs to be strengthened*

54. *India should become a "Full Member of the Washington Award" without further delay for the recognition of the engineering qualifications by other countries*

55. *The administrative set-up for the higher technical education in the country, represented by the UGC and AICTE, needs to be made flexible and purposeful by converting it into a single window set-up or*

as may be deemed appropriate for managing the higher technical education

56. *The demand assessment of engineers from the different sectors of the economy should be made a regular feature of the work of the regulatory body before sanctioning the new engineering colleges,* primarily for arresting *the* proliferation of engineering colleges of poor quality infrastructure and faculty in the country

57. *The exchange of engineers for short periods between academic institutions and the industry should be made a mandatory practice for making engineering education system suitable to the industry and hence engineers employable*

58. *There is a need for legal recognition of PE certification granted as per the systems and procedures of Engineer Mobility Forum (EMP)*

59. *Close interaction of academic institutions with entrepreneurs should be mandated as a social responsibility on the part of academia*

60. *Spending of public money on higher education and research in non-performing universities / institutes should be reduced and the performing institutions should be given more financial grants as encouragement for better quality teaching and research*

61. *Performing teachers should also be given financial rewards (e.g. cash incentives for international journal publications, patents filed, or for bringing any other laurels to the institutions, special remuneration package for course loads above average and so on).*

62. *The faculty jobs need to be made more attractive for the right persons and the CPD of the engineering faculty also needs to be institutionalised*

63. *There should be a mandatory working for the faculty with the industry at least for two-to-three terms of two years each during the entire service period and like-wise practising engineers and eminent engineer consultants with demonstrated achievements in the consultancy should also be involved in teaching engineering for similar tenures*

64. *A National Professiency Evaluation Test (NPET) should be designed & developed for each discipline of engineering separately and the recruitment of engineers without the required NPET score should be legally discouraged*

65. The prestigious Indian Institutes of Technology (IITs) should mentor some lesser known or new engineering colleges for raising their standard

66. *Inter-institute credit transfer should be permitted*

67. *It should be made mandatory for the industry to increase their spending on applied research for increasing over all productivity*

68. *The professional engineering societies in India should have a role in setting the standards and certify engineers by testing them as per their standards and in the accreditation mechanism of engineering education in India*

Suggested contours of reform of the engineering education system needing policy intervention for implementation are given in italics

This background discussion note is based on the gist of keynote presentations & consensus recommendations of the previous seven national conventions & two national conferences & a national workshop organized on the theme of reform of engineering education for better employability of engineers & related themes by the Engineering Council of India during 2006-12 in different parts of the country