Brief Report
On
Engineer's Conclave 2016

1-3 September 2016
IIT Madras

RECOMMENDATIONS

Organized by:

Indian National Academy of Engineering

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Recommendations on Engineering Education

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1. INTRODUCTION

Apart from this introduction this report has eight sections. The idea of a university and the industry's perspective describe two apparently difficult-to-reconcile views of engineering education (EE). The paradigm shift in education adds two dimensions to the classical idea of a university. The engineering education track in the engineers' conclave (EC 2016) attempted to identify the multiple dimensions of EE today as well as the pedagogical and technological tools available to deal with them. The importance of autonomy stresses the need for institutional autonomy as a pre-requisite for improvement in ee. Section vii is a summary of the deliberations of EC 2016. The next section on the value of values stresses the importance of the character-building component of ee. The last section summarises the recommendations with additions by the author to provide cogency and completeness.

2. THE IDEA OF A UNIVERSITY

The university today is built on the ideas of the renaissance thinkers who made three basic assumptions: the lawfulness of the material world, the intrinsic unity of knowledge and the potential for indefinite human progress through education. They believed that the underlying unity in the diversity around us can be unraveled only by scientific inquiry across both the natural sciences and the humanities. 'we still take these most readily into our hearts.. (not the)fragmentation of knowledge' [1]. It was von humboldt in the nineteenth century who advocated the present model of the research university. While research brings passion to teaching, the latter rejuvenates the researcher. The two must therefore go hand-in-hand in the university.

Oakeshott [2] and Chomsky [3] articulate the academic view of a university very well. The research university is a collection of people engaged in "the pursuit of learning" in a special manner as a co-operative enterprise. It is a body of scholars, each devoted to a particular branch of learning, not a machine for achieving a particular purpose or producing a particular result; it is a manner of human activity. Thus scientific activity is not the pursuit of a premeditated end; nobody knows or can imagine where it will reach. What holds the participants together is not a known purpose to be achieved, but the knowledge scientists have of how to conduct a scientific investigation.

"The pursuit of learning" in a university is characterized by two valuable components, namely, the pursuit of knowledge,which has no immediate use and the attention to detail. The world often dismisses erroneouslythe scholars' activityas pedantic when it appears useless.not all scholars are great teachers. But every genuine scholarteachesby the force and inspiration of his knowledge and his immersion in the pursuit oflearning. Education (including engineering and medicine) has nothing to do with vulgarization of learning solely as a means to passing an examination or earning a certificate.

Education is not to be confused with training for a profession, learning the tricks of a trade, preparation for future particular service in society, the acquisition of a kind of moral and intellectual outfit to see a student through life or the pursuit of learning for the power it may bring. The form of its curriculum has no such design and the manner of its teaching has no such intention. Indeed, whenever an ulterior purpose of this sort makes its appearance, education steals out of the back door with noiseless steps. These things that are admirable in themselves but they belong to a world of power and utility and exploitation - a world that is not self-critical and apt to mistake itself for the whole world. It assumes that whatever does not contribute to its own purposes is somehow errant [2].

The traditional ideal of the universities is to foster creative and independent thought and inquiry, challenge perceived beliefs, explore new horizons and forget external constraints. That's an ideal that's no doubt been flawed in practice, but to the extent that it's realized is a good measure of the level of civilization achieved. There's no way to measure the human and social costs of converting schools and universities into facilities that produce commodities for the job market, abandoning their traditional ideal [3].

3. THE INDUSTRY'S PERSPECTIVE

Morell [4] and johansen [5] typify the industry's view of education. Engineering education has to bridge the gap between the world of today and education and address local, regional and global challenges. The engineering graduate requires a new set of soft, professional skills and competencies. A well-qualified talent pool is getting harder and harder to find, in a large measure due to outdated university curricula and poor development of the skills and competencies needed in the workforce. There's a clear disparity between knowledge taught at universities and know-how required at the workplace [4].

In order for a university to be of value to society, it has to understand its needs in terms of the region's economic development and human resources now and in the future, where in the value chain the region wants to be in the future (innovation, manufacturing, marketing, all)? What are the technology niches it wants to nurture or develop? If educationand engineering education in particular is the key foundation for society, all institutions and programs should strive for excellence through continuous quality assessment (internal driver of excellence) and through accreditation (external driver of excellence) [5].

4. THE PARADIGM SHIFT IN ENGINEERING EDUCATION

Engineering education has three major components: knowledge, know-how and character [6]. Knowledge enables one to understand what one learns in relation to what one already knows. It can be organised into intellectually tight compartments and can be conveniently taught as courses in a conventional curriculum. Know-how is the ability to put knowledge to work. It requires the purposeful organization of knowledge from many different areas of learning. Know-how is taught through design courses, project work, industrial training and other opportunities for individual initiative and creativity. Elective courses on technology often provide descriptions of successfully implemented know-how while those on emerging technologies describe attempts at doing so.character is easy to recognize but character-building processes are difficult to define and implement. Character traits such as honesty, truthfulness, integrity, initiative, competitiveness, self-esteem, leadership and the ability to work both alone and as part of a team have an invariant value although it is not all clear how these are imbibed in an educational system that caters to a very large and diverse clientele. The humanities can play a central role while co-curricular activities can play a significant role in building character.

Traditionally, the major activities in the university have been teaching and learning and research. In recent years, there has been a paradigm shift in the way society views education. In the global knowledge economy of today, universities are expected, in addition to their traditional role, to encourage innovation and entrepreneurship and to help increase the gross enrolment ratio.

5. THE ENGINEERS' CONCLAVE

It is important to realize that while the two view-points summarized in sections ii and iii above seem diametrically opposed, both the academic and the industrialist can see reason in the other's plea. The academicis hired in the university for his/ her scholarship and expertise in a research area and isneither interested in nor competent to impart the softskills that the industry demands in the graduates. These useful skills cannot form part of curricular education but they can be gainfully imparted in the university setting through extra/ co-curricular activities supervised primarily by competent industry professionals.

The purpose of this engineering education track in ec 2016 was toidentify the multiple dimensions of education in engineering as well as the pedagogical and technological tools available to deal with them. Sixteeneminent speakers werechosen from the spectrum of stake-holders, and the talks conveniently organisedunder eight sub-heads: curriculum, pedagogy, research excellence, innovation, international benchmarking, MOOCS, industry expectations and skill development. Ten speakers were from the academia, two currently representing national regulatory bodies and the remaining six were from the industry.

Specifically professors UB Desai and Shanthipavan spoke on curricular issues, professors PP Chakrabarty and Sahana murthy on pedagogy, Professors Devangkhakhar and Ramgopalrao on research excellence, Mr. Mm Murugappan and mr. B Santhanam on innovation, Professors Surendra prasad and Anil Sahasrabuddhe on international benchmarking, professors Anant Agarwal and Andrew Thangaraj on moocs, professor Lejahatiangadi and Mr. Sivaganesh on industry expectations, Dr. Cp Ravi kumar and Mr. Varunagarwal on skill development. Each talk was of 20 minutes duration followed by 10 minutes of Q&A. Section vii summarises the deliberations of EC 2016 with additions by the author to provide cogency and completeness.

6. THE IMPORTANCE OF AUTONOMY

Each section of this report makes several recommendations for reform in engineering education. It must be emphasized that autonomy – academic, administrative and financial – is a pre-requisite for improvement in the quality of education offered by an institution. Affiliated colleges are burdened with a heavy curriculum by the affiliating university. These colleges are stuck with the rigidity of the system imposed by the university. On the other hand affiliation helps colleges that offer poor quality education survive by riding on the reputation of the university they are affiliated to.

Only four countries in the world - india, pakistan, sri lanka and bangaladesh - have hung on to the outmoded and colonial idea of affiliation. Some checks and balances are perhaps needed to ensure that autonomy is properly used. These need to be worked out by the ugc/aicte and other regulatory bodies. But, the sooner we get rid of affiliation and the sooner we give our institutions autonomy, the sooner we will see a significant improvement in the quality of higher education in our country. A recent report [8] documents the dramatic improvement in quality achieved within a decade by the college of engineering pune through an enlightened governance given complete autonomy by an enlightened state government.

7. SUMMARY OF THE DELIBERATIONS OF EC 2016

A. Curriculum

It is widely accepted that the ug curriculum should be broad-based and engineering-science based. The curriculum however needs to keep in tune with the changes that have impacted society. Here are some concrete suggestions:

1. Reduce total course load. A heavy curriculum makes education rigid and curtails the freedom of the student to explore subjects outside his specialization and that of the educator to experiment with creative options.
2. Make the curriculum flexible so as to give freedom to the students to pursue courses across disciplines and take multidisciplinary courses, projects etc.
3. Introduce fractional credit courses (one credit courses equivalent to one hour per week for a semester) and limit the weekly contact hours so as to facilitate involvement of experts from outside the system, including the industry as guest faculty. These contact hours could then be distributed over 2 or 3 weeks requiring the expert to visit the institute once or twice during the semester. These would also facilitate introducing courses in liberal arts by practicing artists and professionals from non-engineering fields.

B. Pedagogy

Pedagogy employed in engineering education needs re-examination in the light of the following observations:

1. The role of the teacher has to evolve from that of a mere provider of content to one of a mentor, facilitator and coach. With internet providing easy access to quality content through moocs and other sources, the student is able access recorded lectures /course material in the form of videos, slides etc. Of experts. The perceived burden of the teacher to complete the delivery of the prescribed curriculum within the available contact hours is now greatly relieved. Hence he/she could expose the students to quality contents and play the role of a mentor to stimulate discussions.

2. The focus of the educational system has to shift from teaching to learning, from the teacher to learner. There are many methods of pedagogy that address this and are widely discussed in literature viz.,flipped class rooms, group learning (think-pair-share), project based learning, that can be gainfully employed in the university.

C. Creativity and the university

The university has been the major source of creativity over the past several centuries. Creativity in the knowledge area is described in terms of discovery and invention. That in the know-how area is described in terms of innovation. Sperry and his co-workers have given us some insights into the creative process [9]. The two sides of the brain think in fundamentally different ways: the left thinks in words and uses step-by-step logical sequences. The right brain on the other hand uses visual images and intuition to draw conclusions.the synergistic relationship between the left and right halves of the brain is the real basis of creativity. The freedom from logic and structure is what makes the visual thought process of the right brain so effective in generating ideas. Since most of the ideas so generated fail, when tested logically, the left-brain is equally important in the creative process. Einstein remarked: “the intuitive mind is a sacred gift and the rational mind is a faithful servant. We have created a society that honours the servant and has forgotten the gift”.education in the university emphasizes logic but should learn tonurture intuition. One way to achieve this is by bringing together “unlike” minds: unlike in disciplinary training, in cultural origins and in attitude.

The best examples of creativity resulting from bringing together minds unlike in cultural origin are the graduate schools in the world’s leading universities. While science is universal, the scientist has a cultural background and hence many prejudices. Bringing together minds from different cultural backgrounds can help overcome at least some of them as exemplified by the success of the us graduate schools in generating creative ideas. The remarkable success of the bell labs in the post-war decades of the twentieth century is an example of innovations triggered by bringing together multi-disciplinary groups of researchers to work on problems of societal importance.india should permit internationalisation thus leading to improvement in creativity and ranking.

D. Research excellence

Research is expensive activity. Research expenditure is a good measure of the creativity of a country in today’s global knowledge economy, in which

- Technology, rather than low labour cost, gives the competitive advantage
- High margins are only achieved through intellectual property ownership
- National defence and internal security are increasingly dependent on closely guarded technology controlled nationally and only a subset is available for purchase/licensing

Rank	Country/region	Expenditures on R&D
1	United states	405.3
2	China	337.5
3	Japan	160.3
4	Germany	69.5
5	South korea	65.4
6	France	42.2
7	United kingdom	38.4
8	India	36.1
9	Russia	32.8
10	Canada	24.3
11	Brazil	19.4

- Technology is strongly

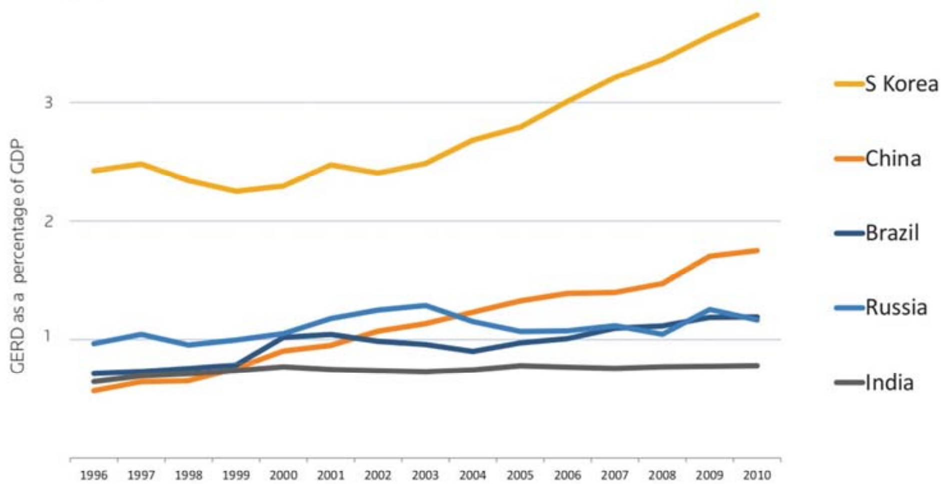
The table above shows where we stand in terms of our investment in research.

In particular the research expenditure of us and china are an order of magnitude more than that of India and this should be a serious cause for concern for our policy makers.

The increase in gross expenditure on r&d is shown as a function of gnp for a few countries in the figure below. Again china is way ahead of us in this regard. The results of such an expenditure in terms of research publications and their impact are also shown in the next two figures.

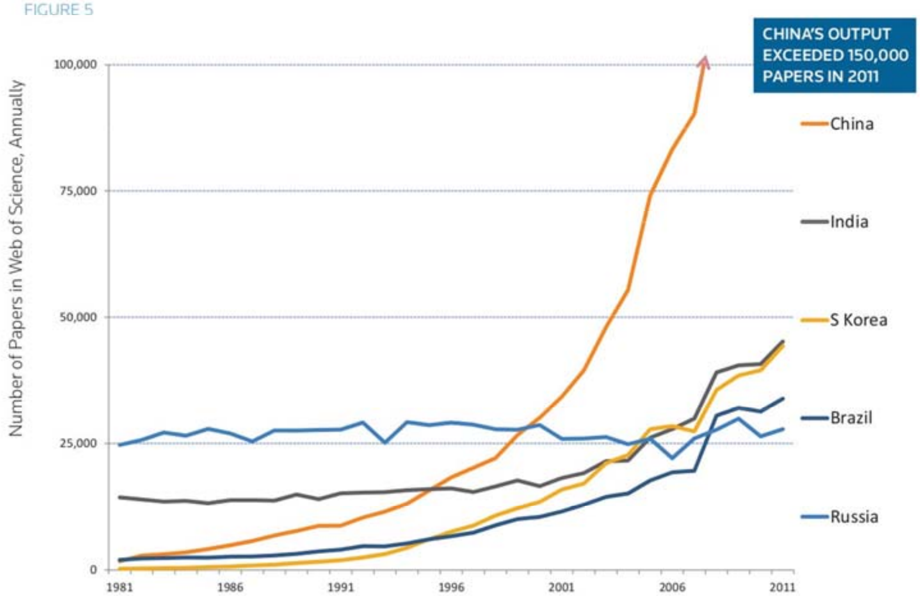
ANNUAL CHANGE IN GROSS EXPENDITURE ON RESEARCH & DEVELOPMENT (GERD) AS A PERCENTAGE OF NATIONAL GROSS DOMESTIC PRODUCT (GDP)

FIGURE 2



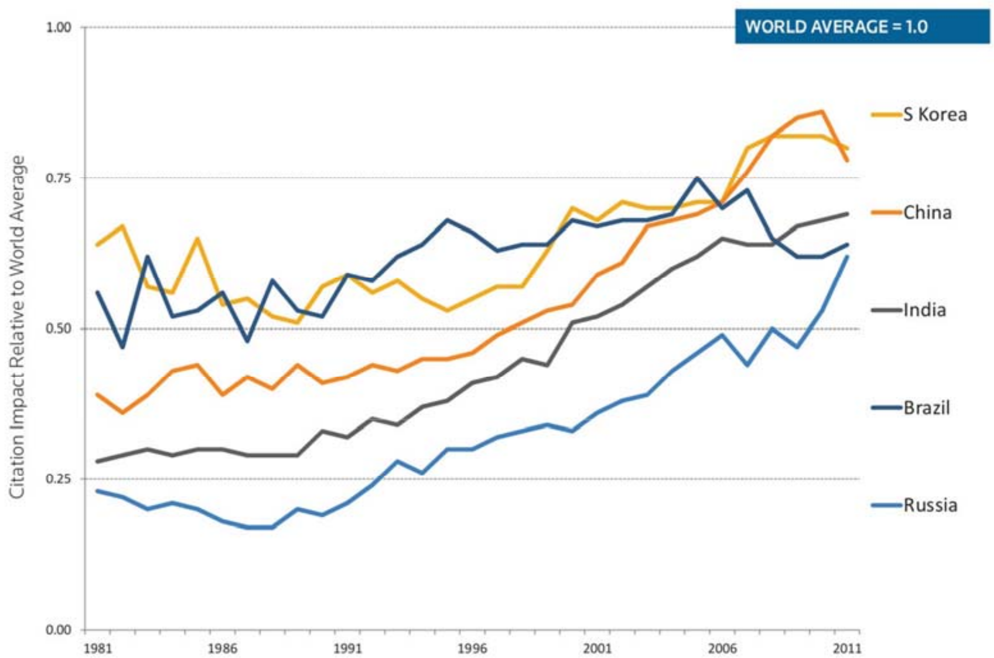
ANNUAL RESEARCH PUBLICATION OUTPUT OF THE FIVE BRICK COUNTRIES

FIGURE 5



CITATION IMPACT OF THE FIVE BRICK COUNTRIES RELATIVE TO WORLD AVERAGE

FIGURE 7



E. Innovation and entrepreneurship

In today's global economy innovation and entrepreneurship are central to a nation's successful participation research universities are the main source of creativity and in the globalised world of today, they need to manage their creativity well.

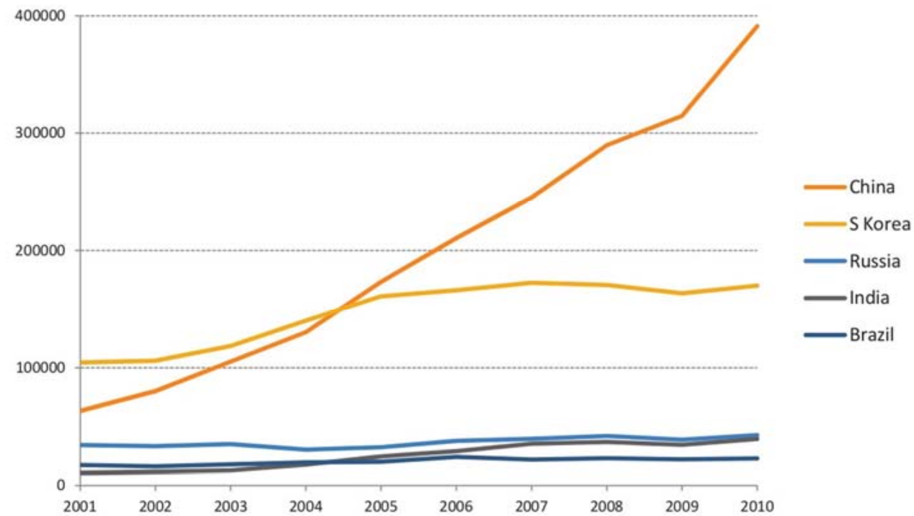
While discovery and invention have little to do with economic consequences, innovation includes a crucial economic component. It is often about extracting value from a creative understanding of what is already known. It has everything to do with commercial success and drives the economy [10].innovation is successfully managed by the 'idea factory' approach - bringing unlike minds together, creating the right atmosphere and giving them freedom but carefully structuring interactions [10].

It is universally recognized today that innovation and entrepreneurship are best promoted through university research parks that bring together minds with different attitudes: faculty with a knowledge of the fundamentals; students with their spirit to conquer and s&t personnel from the industry with their ability to convert ideas into marketable products [11].the university research park (urp), a property-based venture located near a university campus, creates a local concentration of skills and technology, promotes innovation, competitiveness and entrepreneurship. It helps convert research ideas into innovative technologies, houses R&D of companies, creates and nurtures start-ups and drives technology-led regional economic development.

Louis Pasteur is reported to have said, " ..discovery is the result of chance meeting a prepared mind ..". A significant fraction of iprs in the 90s in silicon valley have names of iit alumni associated with them. It appears that iits have been preparing minds and chance has been meeting them in silicon valley! This is one of the reasons why iitm sought the permission and partial financial support from the ministry of human resources development (mhrd) in 2002 to set-up the iit madras research park (iitmrp) as a section 8 (non-profit) company. Simultaneously iitm also approached the state government for the grant of 11.5 acres land and associated infrastructure in the vicinity of its campus. The funds were raised from five sources: a grant from mhrd, a loan from a bank, 20-year rentals, internal accruals and alumni donations. The aim was to create 1.2 lakh sq.m to house r&d of companies (85%) and incubatees (15%) and create opportunities for access to venture capital, legal advice etc.,. The iitmrp, in its very first year (2010), filed over 50 patents. The website – http://respark.iitm.ac.in - has more information on the iitmrp. The share of private sector in r&d in india is about 34% of gerd (as against the global benchmarks of 65-80%) and should increase. While there is a reasonable correlation between government investment in research and research publications in recent years, the monetization of research findings into commercial products has been rather poor. The figure below shows that he number of patents filed has not increased significantly.

ANNUAL NUMBER OF INVENTION PATENT APPLICATIONS FILED BY THE FIVE BRICK COUNTRIES

FIGURE 11



Here are some observations and recommendations on what academic institutions should do in this regard:

1. Encourage and incubate student start-ups and promote the ecosystem for enabling industry-academia interactions.

2. Increase the exposure and hands-on-experience of ug and pg students to emerging research areas, design innovation, entrepreneurship, ip issues and societal concerns.

3. Establish major centers of research excellence and socially relevance.

4. Develop products for local consumption through indigenous research, addressing the needs of large sections of society. Venture capital and governmental support for large scale field-testing is necessary for scaling up of the high-tech research devices into commercial products. Then such product development will lead to the starting of a manufacturing company.

5. A government-supported large-scale centralized fabrication facility available for use by entrepreneurs and academia can help overcome some of the problems faced by high tech startups.

All of these are best promoted through the establishment of URPS.

Today innovation forms the basis for finding solutions to the vital needs of society and also for big business ventures. Moreover since the risk of obsolescence is the greatest threat, R&D has become an essential part of business competitiveness. High technology and innovation alone create sustainable competitive advantage for an industry. However, from an innovative concept to a successful commercial product, there are several steps: basic research, applied research, device development and industrial scale testing.

One should always strive to move from existing core technology towards transformational technology in order to retain the competitive edge. In the present industrial scenario, product cycles are becoming shorter and it is very difficult to bring about total technological changes without external collaboration. It is important to network with academic or research institutions in the form of a national innovative ecosystem or even collaborate with international research teams. With a value-creation focus and targeted problem-solving approach, such interactions could be profitable to all the stakeholders. The necessary ecosystem can be created in the form research parks, effective systems for ip rights, support for academic entrepreneurs and ppp models for research.

Open innovation is an important part of cost-effective innovation. Open innovation reduces the product development time and investment. The strategy of open innovation involves ‘connect and collaborate’ to ‘create and change’. Apart from the internal research efforts, if resources external to the company in the form of tie-ups with academic institutes or start-up companies and expert networks can be leveraged, a successful open innovation model can be developed. In fact, co-creation of products with customer interactions is also possible. Instead of resorting to a fully home-grown research and development plan, a combinatorial approach to combine different existing ideas can also form the basis of a successful business model. Already there are several instances of successful collaboration across multiple science and technological domains viz., with iit madras through iitm research park. Great opportunities for innovation exist with respect to the fundamental human needs of water, energy and habitat.

F. International benchmarking

International benchmarking is about settling levels of attainment for indian higher education at par with the global best with relevance to india. Its dimensions include ranking, progress in setting and executing accreditation standards, research culture and accessibility of education to all. From the student's point of view accreditation ensures quality education delivery, improved learning environment, good faculty and accountability. For the institution it providesa clarityin terms of learning outcomes; requires continuous assessment and helps develop insights resulting in overall improvement in pedagogy.accreditation is the seal of approval to the institute that their programmes satisfy stakeholders and a continuous improvement system is in place. Criteria 7 of the nba focuses on continuous improvement and places emphasis on outcome based delivery. In research the focus is on impactful research. Find new areas and new ways of assessing research quality. Furthermore perception of research quality is also important.

Increasing the accessibility of education requires new financial models to support student expenses. Benchmarking looks at aspirations. The tools used include self-assessment, organization and management, learning resources, experts interaction and continuous improvement. India specific parameters include access, equity, inclusivity and employability. Complexity of the indian higher education system makes the process difficult. Overlap of responsibilities between the UGC, the pharmacy council, architecture council and aicte is an added complication. Another is the creation of excess seats of dubious quality in recent decades: number of colleges closing down has gone up in the recent past with40% of seats not allotted. Success stories in benchmarking from universities in east asia can serve as models to be emulated. Internationalization of institutes is an urgent issue that needs careful study and early implementation.

G. Increasing the GER

To compete successfully in the globalised knowledge economy of today, it is generally accepted that the ger in higher education should be at least 30%. Some figures in this context are: India 15, China 30, US 80 % and so on. Given the size of our population, going from a ger of 23% to 30% by traditional means will require, inter-alia, the creation of one brick-and-mortar institution every week! Furthermore there is a severe shortage of faculty that cannot be overcome in a short time. The creation of a virtual university is india’s only option. A pre-requisite for the virtual university is the creation of open courseware and massive online education.

The national programme on technology enhanced learning (NPTEL) was initiated by iit madras, supported by the other iits and funded by the mhrd in 2003. Today NPTEL is the world’s largest collection of open course-ware with the over 700 modular courses each in web/ video formats. For the interested reader, the website: http://www.nptel.iitm.ac.in has more details.

massive open online courseware (MOOC) providers aim to increase the reach of education and reduce its cost. There are many MOOC providers world-wide, viz,mit's edx. Some open platform allows the creation of a lot of online learning portals. The savings in time and cost through use of MOOCs is described in terms of 'unbundling the clock, credentials and contents'. Thus unbundling the clock is about saving in time by learning, say, 1 year on edx and transfering the credits earned to a local university. For example, the global freshman academy - Arizona state university on edx – has free courses for everyone. The student only pays asu the admission fee to earn credits if he/ she passes the course. An example of unbundling credentials is the micromastersprogramme: 4-5 courses are offered free online and the candidate who passes the courses pays $1000 to mit for earning credit. Then he or she can enrol for full masters at half the cost. Unbundling contents refers to using the contents from edx to flip the classroom at the local university. Evaluations - equations, essays, image response, drag and drop answers - are done by the computers. Analytics are provided for instructors on student performance. Student integrity on moocs is ensured through timed examinations, controlled exam visbility, randomzied problems and virtual proctoring (video recorded during student taking the exam using a webcam is reviewed by an outsourced agencies). Hands-on experience is provided through virtual labs. In the near future the 'unbundled university' will change the structure of learning.

For india the central question is whether technology can be used to provide high quality education at affordable cost. The largest collection of open courseware in technical education in the world, NPTEL (national) has seen over 500 million hits. Noc - nptel online certificate – has been offered since 2014. Open online courses are followed by a proctored exam. Certificate is given on successful completion. Open online courses have no entry criteria and are far less expensive. What they lack is peer-interactions compared to on-campus education. This exercise should be supported by funding from mhrd and CSR funding from the industry. A unique feature of nptel is its engagement with local colleges and with industry. There are now 600+ local chapters and an nptel page for each local chapter.

The online course portal of nptel offers discussion forums, support for content creation, mentorship, etc. Since may 2014, 122 courses have been completed and 105 courses are running in the current semester (july - nov 2016). The statistics are impressive: 1 million course enrollments, 55000+ exam registrations. 16% of those enrolled are employed already, 4% are neither students nor employed. Of those registered for the exam 10% are faculty. Evaluations consists of some online assignments plus a proctored exam that has a mix of subjective and multiple-choice questions.

In this context india should look at the possibility of setting up a 'virtual university' (vu) for engineering education. With careful planning and in ppp mode the vu can provide the reach as well as quality that have been so elusive so far. Nptel courses can form a base for the launch of the vu.

H. The role of industry in education

Education tends to be theoretical; not grounded in practical aspects. For example, students today graduate without seeing a real plant.the university should play an enabling role in the implementation of the following recommendations/ observations:

1. The university by itself is not equipped to impart some of the skill-sets that the industry requires in a graduating engineer like communication skills, cognitive skills, functional skills, personality / attitude and soft skills. These can be imparted to the students as part of co-curricular requirements with the help of the industry.

2. The industry should be invited to share some of their empirical knowledge of specific systems, give 'reality-check' lectures on design in the appropriate courses and participate in the definition and execution of projects

3. Industry requirements in graduates vary widely between different sectors and different industries (startup/multinational/psu/etc.) And awareness workshops by industry personnel for students should be organised on campus.

4. Employability gap needs to be examined especially in students from tier-2 and tier-3 institutions. Innovative use of technology to bridge this gap would be essential in india.

5. Modes of possible interactions for industries: student internships, plant visits or educative videos of plants sent to institutions, campus interviews (instead of walk-in interviews), participation in boards of studies, sponsorship of projects, guest lectures etc.

6. Modes of possible interactions for academics: provide refresher courses, teach new analysis tools, engage in "blue-sky" discussions, guest lectures in industry, etc.

7. Both sides should invest in assessing outcomes of various approaches.

8. Outdated concepts remain in the curriculum because they are asked in exams/interviews; they are asked in exams/interviews since they remain a part of fundamental curriculum. It is necessary to work together to break this cycle and keep the curriculum updated and relevant.

9. Industry personnel should address the student chapters of professional associations to create an awareness of innovative and useful multi-disciplinary applications of what is learnt in the university.

10. In research the interaction is of mutual benefit and the most effective interactions are through the university based research parks described earlier.

The university seeks unity in the wild diversity around us while the industry thrives on differences. After all the industry can't sell its product competitively unless it is superior in some respect to similar products that other industries produce. In all its interactions with the industry the university will do well to remember that the values of the university are different from those in the market-place. Monetary incentives, as the late charles vest remarked, "are the last gasp of an (educational) institution in trouble"[12].

8. THE VALUE OF VALUES

Of the three components of education – knowledge, know-how and character, character has now become the most important attribute for the survival of civilization as a whole. One way to build character is through education in values, mostly inspired by the great scriptures and epics. Since ancient times, this education has been through informal structures of learning mediated by the extended family, the public discourses about the perennial struggles of good and evil and the practical decisions of the village panchayats and in recent decades by the law [13]. The first three appear to be breaking down while the fourth is too technical to be a substitute for true education in values.

It is perhaps more pragmatic to teach college students the 'value of values' [14]. Non-violence is the only universal value. Students should learn that the value of non-violence is far greater than the value of money or of power or of the fulfillment of one's desires and that they are welcome to acquire these by non-violent means! Lord krishna tells us in the bhagavad gita, "if you walk the path of dharma, i will walk with you, otherwise you walk alone". Walking alone is not a sustainable proposition for human beings.

9. RECOMMENDATIONS

A. Autonomy:

1. Affiliation constrains the good institutions and helps the bad ones survive. The sooner we get rid of affiliation and the sooner we give our institutions autonomy, the sooner we will see a significant improvement in the quality of higher education in our country.

B. Curriculum

2. Ug curriculum should be broad-based and engineering-science based.

3. A heavy curriculum makes education rigid and curtails the freedom of the student to explore subjects outside his/ her specialization and that of the educator to experiment with creative options. Reduce total course load.

4. Make the curriculum flexible so as to give freedom to the students to pursue courses across disciplines and take multidisciplinary courses, projects etc.

5. Introduce fractional credit courses (one credit courses equivalent to one hour per week for a semester) and limit the weekly contact hours so as to facilitate involvement of experts from outside the system, including those from the industry as guest faculty.

C. Pedagogy

6. Pedagogy employed in engineering education needs re-examination in the light of the following observations:

7. The teacher should expose the students to quality contents on the internet and through moocs and play the role of a mentor, facilitator and coach to stimulate discussions.

8. The focus of the educational system has to shift from teaching to learning, from the teacher to learner. There are many methods of pedagogy that address this and are widely discussed in literature viz., flipped class rooms, group learning (think-pair-share), project based learning, that can be gainfully employed in the university.

D. Creativity and the university

9. Education in the university emphasizes logic but should learn to nurture intuition. One way to achieve this is by bringing together minds unlike in disciplinary training, in cultural origins and in attitude.

10. India should permit internationalisation thus leading to improvement in creativity and ranking.

E. Research excellence

11. Research is the best investment for the future of a nation. The research expenditure of us and china are an order of magnitude more than that of india and this should be a serious cause for concern for our policy makers.

12. As far as the increase in gross expenditure on R&D as a function of gnp is concerned, china is way ahead of us in this regard.

F. Innovation and entrepreneurship

13. The share of private sector in R&D in india is about 34% of gerd (as against the global benchmark of 65-80%) and should be increased.

14. Encourage and incubate student start-ups and promote the ecosystem for enabling industry-academia interactions.

15. Increase the exposure and hands-on-experience of ug and pg students to emerging research areas, design innovation, entrepreneurship, ip issues and societal concerns.

16. Establish major centers of research excellence and social relevance.

17. Develop products for local consumption through indigenous research, addressing the needs of large sections of society. Venture capital and governmental support for large scale field-testing is necessary for scaling up of the high-tech research devices into commercial products. Then such product development will lead to the starting of a manufacturing company.

18. A successful open innovation model needs to be developed. Already there are several instances of successful collaboration across multiple science and technological domains with iit madras through the iitm research park.

19. It is universally recognized today that innovation and entrepreneurship are best promoted through university research parks (urp). The first of these in India, the iitmrp (http://respark.iitm.ac.in), in its very first year (2010), filed over 50 patents.

20. A government-supported large-scale centralized fabrication facility for use by entrepreneurs and academia is a must to overcome some of the problems faced by high tech startups.

G. International benchmarking

21. Success stories in benchmarking from universities in east asia can serve as models to be emulated.

22. Internationalization of institutes is an urgent issue that needs careful study and early implementation.

H. Increasing the GER

23. Going from a GER of 23% to 30% by traditional means will require the creation of a virtual university (vu). With careful planning and in ppp mode the vu can provide the reach as well as quality that have been so elusive so far. Nptel courses can form a base for the launch of the vu.

24. A pre-requisite for the vu is the creation of open courseware and massive online education. Today nptel is the world's largest collection of open course-ware with over 700 modular courses each in web/ video formats (http://www.nptel.iitm.ac.in). This effort should continue with liberal support from mhrd.

25. Massive open online courseware (mooc) providers aim to increase the reach of education and reduce its cost. Noc - nptel online certificate – has been offered since 2014. This exercise should be supported by funding from mhrd and csr funding from the industry.

26. The online course portal of NPTEL offers discussion forums, support for content creation, mentorship, etc. Since May 2014, 122 courses have been completed and 105 courses are running in the current semester (july - nov 2016). The statistics are impressive: 1 million course enrollments, 55000+ exam registrations. 16% of those enrolled are employed already, 4% are neither students nor employed. Of those registered for the exam 10% are faculty. This effort should be supported liberally by MHRD

I. The role of industry in education

27. Some of the skill-sets that the industry requires in a graduating engineer like communication skills, cognitive skills, functional skills, personality / attitude and soft skills can only be effectively imparted to the students as part of co-curricular requirements with the help of the industry.

28. The industry should be invited to share some of their empirical knowledge of specific systems, give 'reality-check' lectures on design in the appropriate courses and participate in the definition and execution of projects

29. Industry requirements in graduates vary widely between different sectors and different industries (startup/multinational/psu/etc.) And awareness workshops by industry personnel for students should be organised on campus.

30. Employability gap in students from tier-2 and tier-3 institutions in india can be bridged only by innovative use of technology.

31. Modes of possible interactions for industries: student internships, plant visits or educative videos of plants sent to institutions, campus interviews (instead of walk-in interviews), participation in boards of studies, sponsorship of projects, guest lectures etc.

32. Modes of possible interactions for academics: provide refresher courses, teach new analysis tools, engage in "blue-sky" discussions, guest lectures in industry, etc.

33. Both sides should invest in assessing outcomes of various approaches.

34. Outdated concepts remain in the curriculum because they are asked in exams/interviews; they are asked in exams/interviews since they remain a part of fundamental curriculum. It is necessary to work together to break this cycle and keep the curriculum updated and relevant.

35. Industry personnel should address the student chapters of professional associations to create an awareness of innovative and useful multi-disciplinary applications of what is learnt in the university.

36. In research the interaction is of mutual benefit and the most effective interactions are through the university based research parks described earlier.

J. Building character

37. It is perhaps pragmatic to teach college students the 'value of values': non-violence is the only universal value. Students should learn that the value of non-violence is far greater than the value of money or of power or of the fulfillment of one's desires and that they are welcome to acquire these only by non-violent means!

38. Students should be exposed to leaders from all walks of life as part of extra-curricular activities.

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Recommendations on "Smart Cities"

Engineer's Conclave –Sept 1-3, 2016 held at IIT Madras

1. INTRODUCTION

India is experiencing a clear trend in urbanization, whereby a sizable rural population is continually moving to Cities. Projections are bound to vary but it is quite possible that close to 600 million people may be living in Indian Cities by the year 2030, and, possibly 840 million by 2050. Furthermore, urban development has not been able to receive hitherto, as much attention as is necessary, and this leaves Indian cities even for their current population size, to be deficient in most facets such as, energy, water management, sanitation and waste disposal, housing, transportation, governance, and so on. These two factors combined make it imperative that the issue is addressed urgently. The task of making Indian cities more comfortable to live in, and, to grow economically as well, so as to serve the population across the spectrum, is a mammoth exercise. However, the enormous developments and growth during the recent decades, in electronics, communications, IT, and, technologies in general, has raised a profound hope for meeting various challenges – efficient urbanization being an important one.

'Smart City', a buzz word of recent years, is a concept whereby the utilization of modern technologies can lead to a more efficient deployment of resources, limited as they are, for serving the objectives of economic growth, various services responding more smartly, smarter governance, and, by and large a more comfortable living for the city populations . This would involve, smart transportation, energy efficiency, smart water management, automatic data collection, recording and controls, etc.

Considering the urgency of the need for sprucing up the cities, the Government of India, Ministry of Urban Development, has launched a major mission on 'Smart Cities', and selected a number of cities (60 so far) for special attention and funding. This number is expected to increase to a 100. It was hoped that the deliberations on this subject area during the Conclave will help to identify ideas useful for supporting the mission. Considering the elements which could be more relevant to the 'Smart City' activities, the presentations were divided into four themes :

1. Transportation and Architecture
2. Urban Water Management
3. E-Governance and ICT
4. Energy and Ecology

The INAE was fortunate in identifying eminent speakers to share their expertise and experience in the subject area with the participants. The presentations made are listed in the Table II.1.

Based on these, the deliberations held during the sessions, and, subsequent analyses, a set of recommendations are included in this note.

Table II.1 : Technical Session I - Transportation And Architecture

(a) SMART TRANSPORTATION FOR SMART CITIES by Dr. P. K. Sikdar, President and COO, ICT Pvt. Ltd, New Delhi, India

(b) TELECOM INFRASTRUCTURE AND STANDARDS FOR SMART CITIES by Dr. Kumar Sivarajan, Chief Technology Officer, Tejas Networks Ltd, Bangalore

(c) SMART HOUSING by Dr. K. N. Satyanarayana, Professor, Department of Civil Engineering, IIT Madras

(d) HOW DOES DATA AFFECT SMART CITIES? by Mr. Bipin Kumar, Founder and Director, Gaia Smart Cities, New Delhi

TECHNICAL SESSION II- URBAN WATER MANAGEMENT

(a) WATER RECYCLING AND REUSE IN THE CONTEXT OF URBANISATION AND UPCOMING SMART CITIES IN INDIA by Dr. R. Venkataraman, Formerly ISRO, Bangalore

(b) ZLD APPROACH EMPLOYING ON-SITE / DECENTRALIZED WASTEWATER TREATMENT FOR WATER CONSERVATION IN SMART CITIES by Dr. Ligy Philip, Professor, Department of Civil Engineering, IIT Madras

(c) PLAYING WITH WATER: FOR LIFE AND FOR BUSINESS by Prof. Vinod Tare, Professor, Department of Civil Engineering, IIT Kanpur

(d) HOW CAN WE DELIVER 24X7 DRINKING WATER IN INDIAN CITIES? - INSIGHTS FROM GOOD PRACTICES IN ASIAN CITIES by Dr. K. E. Seetharam, Asian Development Bank, Manila, Philippines

TECHNICAL SESSION III - e - GOVERNANCE / ICT ENABLING

(a) e - GOVERNANCE AND IT ENABLED SERVICES by Mr. K. Ananthkrishnan, Chief Technology Officer, Tata Consultancy Services, Chennai

(b) STRATEGIC MOBILITY PLANNING FOR SMART CITIES by Ms. Shreya Gadepalli, Regional Director, ITDP, India

(c) A FRAMEWORK FOR e - GOVERNANCE AT THE STATE LEVEL: THE TAMILNADU MODEL by Mr. T. K Ramachandran, IAS, Principal Secretary, IT Department, Government of Tamil Nadu

(d) MOBILEONE by Mr. Krishna Bajpai, IAS, Controller of Examination, Karnataka Public Service Commission, Bengaluru.

TECHNICAL SESSION IV - ENERGY AND ECOLOGY

(a) SMART SOLAR POWER FOR HOMES IN SMART CITIES by Dr. Ashok Jhunjhunwala, Professor, Department of Electrical Engineering, IIT Madras

(b) BUILDING AUTOMATION by Dr. Sthaladipti Saha, Larsen and Toubro

(c) OPERATING EXPERIENCE OF A 100 TPD MSW PROCESSING FACILITY IN GOA by Mr. M. Kumaraguru, Vice President SFC Environmental Technologies Pvt. Ltd

Summary Recommendations

Transportation

- Strengthen public transport to cope up with the volume of traffic. Ultimate transport solution for cities will only be fast adoption of Rapid Mass Transport System and discouraging people to use cars for their day to day transport, practically eliminating daily car usage.

  - Fast bus corridors to be created along all main roads, for rapid mass transport, buses should be able to run to average speed of 30 to 50 Km/hr. This can be achieved only by reducing the cars on these roads by bringing confidence in people for fast movement by BRT. BRT to be modernized, like Metro.

  - No parking to be allowed on main roads, to decongest roads, to increase BRT speed.

- The judicious mix of the different modes is required to be adopted. Typically, this is exemplified by Fig II.1 (from Dr. PK Sikdar's slide). Commuting can be made smart enough by the use of the e-systems(Data collection, retrieval and dissemination through smart technologies), to permit the traveller to plan his commuting in the most efficient manner.

- Street lamp posts can become an excellent source for traffic planning as well as control, if suitably instrumented and networked (these have many other applications in respect of the life of a city). This can help synchronise signalling and thereby reduce travel time, cost and pollution.

Solid Waste Management

- Solid Waste (mis) Management is the scourge for most cities in the country and those that are going to be made into 'Smart Cities' are no exception. There is as yet little experience in this regard to hold out a hope. However, a 100 tonnes per day solid waste management facility has been designed to be tried out in Goa. If successful this can provide a model for adoption. Cost and efficiency will need to improve with respect to the present status.

- In the context of management of waste from night soil, it was brought out that the use of 'Septic Tanks' or 'Pit Latrines', on a scale being envisaged under the Swachh Bharat Abhiyan, could cause pollution of the ground water. It is recommended that 'dry toilets' (with zero discharge) may be adopted to overcome this possible risk.

Water Management

- Double pipe network is essential to carry potable water separately from that required for all other uses such as washing, gardening etc. The total of 135 l/d/p can be divided as Potable water (35/l/d/p) & recycled water (100/l/d/p). A double pricing arrangement can be adopted for the two types of water. Smart monitoring and smart metering is an important part of developing the system.

- The double pipe water system needs to be decentralised and can be adopted at multiple levels, such as, community housing, apartment block level, and ward level. This will cut down casts and losses due to the use of long piping systems.

- Technologies for treatment & recycling of waste water exist as demonstrated through the presentations made. Thus all waste water can be recycled and utilised. It is possible to close the loop by adopting the approach of "reduce, recycle and reuse", and ascertain zero Liquid Discharge.

Housing

- Smart housing implies use of latest e-technologies to move towards the ‘green buildings’ concept by saving energy, besides providing maximum comfort. Such housing has to be eco-friendly and should have elements of flexibility of use for inhabitants in different age bands.

- However, in the context of the trends in urbanisation, there is a dire housing shortage too (almost 2 crores in the urban areas- a good part of this being in smart cities too). This has to be overcome speedily. Obviously this cannot happen by the ‘as is’ approach. New technologies for construction and new materials (moving away from conventional) may provide part answers. Work at IIT Madras has demonstrated the use of “Glass Fibre Reinforced Gypsum” towards this end.

- Similarly the use of BIM (Building Information Management), though in a state of infancy as yet, has potential for the future planning & design of housing and can smarten up the process by bringing in greater speed and a more complete comprehension of a project.

Energy For Housing

- India is veering consciously towards the generation of power through sources such as wind and solar to reduce the gap between availability and demand. Solar power is obviously an attractive solution in the context of the ‘Smart’ city development. Research at IITM has demonstrated the use of solar power for domestic consumption, moving to the use of DC rather than the common use of AC. It has been shown that this would cut losses substantially.

- IITM has proven over 5000 houses in remotely located houses in Rajasthan, the technological conclusion that DC supply at home is 30 to 40% more efficient, if adopted at a large scale.

- For DC power to be adopted for houses at large scale, it is most important that we adopt a standard DC voltage for the country. Work at IITM has shown that 48 volt DC is safe and optimum. In this context, it is recommended that 48 volt DC as standard for India may be adopted by the Govt. of India , so that Industry may develop all equipments, LED bulbs, fans, Washing Machines, Ovens, Dish Washers, Mixie etc. for 48 volt DC.

- With DC, average Indian house needs can be met by Solar power of 500 to 1 KW (without air conditioning). This enables each house to have solar power system at a cost between Rs. 20,000 to 1 lakh. Also solar power will be affordable at apartments and community levels. This will reduce demand of power from the grid, adding to green India.

- India also needs subsequently to standardize high DC voltage grid for larger consumption like AC, light industry etc. and it is recommended to have 380 volts DC supply. Once standardized, all 440 volts 3- phase equivalent industry equipment can be redesigned for 380 volts DC.

E-Governance

- Smart city has to have IT based e-governance, integrating all state departments with common access and enabling citizens to avail services without need to go to offices except for physical presence like driving tests.

- Country has basic IT technology, however, the IT network has to be strengthened in every city and services application has to be continuously involved with participation of the IT industry and consumer (citizen).

- Various states are developing IT services for public. As examples, Karnataka has developed Mobile One and Tamil Nadu is developing cloud based e-governance based services. A significant step taken by TN is to ensure training of involved personnel for capacity building.

- The concept of e-governance has to have paradigm shift from just computerization of records, payments and information to citizen centric services and enabling e-governance has to go steps ahead of Railways or Airline reservation which nevertheless have done very well.

- As mentioned earlier too, a proposal of great potential, recommended for adoption, is to utilise lamp posts, duly wired with sensors, and interconnected into suitable arrays, using optical fiber. The purpose will be to collect data at each post and store/transfer or retrieve data as needed. The scope of coverage for the functions of this technology can be very large – details of parking and traffic, environmental details, surveillance, service delivery points and multifarious issues of governance.

INDIAN NATIONAL ACADEMY OF ENGINEERING

The Indian National Academy of Engineering (INAE), founded in 1987, comprises India's most distinguished engineers, engineer-scientists and technologists covering the entire spectrum of engineering disciplines. The aims and objects of the Academy are to promote and advance the practice of engineering and technology, related sciences and disciplines and their applications to problems of national importance. INAE also encourages inventions, investigations, and research in pursuit of excellence in the field of “Engineering”.

INAE had taken an initiative of organizing an annual mega event of engineers as “Engineers Conclave” starting from year 2013, essentially to provide a platform for all engineers/scientists to deliberate and address major engineering challenges and opportunities of vital concern and relevance to the country and society. The “Engineers Conclave” is organized by INAE jointly with one of the premier engineering organizations/institutions of the country each year. There are two themes for the Conclave, both focusing on the issues relevant to the Country. While the theme-1 will be decided by the host department, the theme-2 specific to some social problem where engineering intervention is desired, will be decided by INAE. The discussions in the two themes will be focused in finding engineering solutions to the challenges with specific recommendations which would be forwarded to the concerned Departments/Industry for consideration.

For more details, please visit INAE website www.inae.in

Indian National Academy of Engineering
Unit No 604-609, SPAZE, I-Tech Park, 6th Floor, Tower A, Sector 49,
Sohna Road, Gurgaon 122018
Phone: 0124-4239480 Fax: 0124-4239481
email: inaehq@inae.in, website : www.inae.in

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