Emerging Trends in Engineering Education – Indian Perspectives

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Abstract

A SWOT analysis provides a glimpse into the national technology education system. The role of the All India Council for Technical Education (AICTE) is highlighted. The recently announced National Mission for Technical Education provides the strategic directions for the future. A SWOT analysis of an Engineering Professional, a comparison of the XX and XXI century Engineers, and the distinctive characteristics of XXI century Learners and Teachers illustrate the challenges ahead. The globalisation and internationalisation perspectives and the cultural impact of globalisation are next discussed. The national Quality and Accreditation initiatives are described, and the challenge of the Digital Divide is highlighted. The importance of Partnership and Collaboration, in general, and of nurturing Alumni-Alma Mater Relationship are stressed. Finally, some recommendations of a recent ATN-IITs Conference are indicated.

1. A Swot Analysis of The National Technology Education System

Table I provides a SWOT analysis highlighting the distinctive characteristics of the National Technology Education System.

2. The Role of AICTE In The National Technology Education System

The All India Council for Technical Education (AICTE) Act was passed by both the Houses of Parliament in 1987, with the mandate to ensure “the proper planning and coordinated development of the technical education system throughout the country, the promotion of qualitative improvements of such education in relation to planned quantitative growth, and the regulation and proper maintenance of norms and standards in the technical education system and for matters connected therewith”. Among other things, the Powers and Functions of the Council include: technical manpower assessment; coordinated development of technical education in the country at all levels; disbursement of grants to institutions, promotion of R&D and innovations; promoting technical education for women, physically challenged and weaker sections of the society; promotion of an effective link between the technical education system and other relevant systems; evolution of performance appraisal systems for technical institutions; Faculty development; laying down norms and standards; fixing norms and guidelines for fees; grant of approval for starting new technical institutions and programs; grant of charter to professional societies; laying down norms for granting autonomy to technical institutions; steps to prevent commercialization; guidelines for student admissions; inspection of technical institutions; steps to ensure compliance with the directions of the Council; and establishing and sustaining the National Board of Accreditation.

3. The National Mission for Technology Education

The Ministry of Human Resource Development announced this Mission on January 10, 2002, with the main objective “to prepare and implement a long-term strategy for Technical Education in the Country”.

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The Terms of Reference of the Mission include: the laying down of policy for expansion of the highest quality of technical and management education in the country; planning for a substantial expansion in the technical manpower, particularly in new and emerging areas; developing India as an internationally acclaimed technical and management center; ensuring balanced regional development of technical and management education in the country; promotion of postgraduate education and research in higher technical institutions; and overseeing the several initiatives of the government such as accreditation and quality assurance.

Table II highlights the SWOT of an Engineering Professional.

5. A Comparison of The XX And XXI Century Engineers
Table III brings out a comparison of the desirable characteristics of XX and XXI century engineers.

6. XXI Century Learners And Teachers.
The XXI Century learners: have never wound a watch, touched a typewriter, played a record album, calculated with a slide rule, traveled in a steam engine, handwritten a letter, nor known a world without computers. Today’s school kids know more about technology than do their teachers. They get bored, if they are doing only one function at a time; they need multiple stimuli. For example, they watch their computer screens, listen to music through headphones, and carry on conversation, all at the same time. They have short attention spans, and have the attitude of take-it-all-at-once.

The XXI century teachers have several challenges to overcome. “The teacher is no longer the sage on the stage, but the guide on the side.” The teacher is becoming less central to the learning process. Learning with technology has to start by educating the teachers.

7. Stakeholders In The Engineering Education System
Table IV depicts the stakeholder relationships and the value addition achieved in the Engineering Education System.

8. Globalisation and Internationalisation Perspectives

8.1 Globalisation of Higher Education.
- The rationales for globalisation are quite different for developed and developing countries.
  - **Economy**: While for DCs, it is for favorable trading opportunities and expanded markets; for LDCs it is: deregulation, enhanced privatization and currency integration.
  - **Education**: While for DCs, it is for enhanced markets for educational products, processes and services, and for making up for reduced indigenous demand; for LDCs, it means study opportunities abroad, for those who can afford, and competition to local institutions.
  - **Employment**: While for DCs, it leads to erosion of jobs and competition from low-wage workforce from LDCs; for LDCs it leads to off-shore jobs and opportunities for short-term employment abroad.

- Globalisation essentially deals with the processes leading to the integration of the economies of the world, and the acceptance of the market economy world-wide. It has made the nations of the world inter-dependent and inter-connected.

- There are two contrasting/conflicting views on the cultural impact of the globalisation process: in terms of cultural imperialism, increasing homogenization, or what is popularly known as McDonaldisation or Coca-colonisation; or celebration of the creation of the “Global Village.”
leading to the demise of the nation-state, and the availability of increasing range of choices, in terms of: lifestyles, values, technology, commodities, information, entertainment, etc.

- The ‘global economy’ is also an “informational economy”, in which the method of production has shifted from: the mass production of goods at a centralized location (Fordism) to a flexible system of production (post-Fordism) at dispersed locations.

- The impact of globalisation in India, leading to the opening up of the Indian economy, as part of the structural adjustment program, launched under the directive of the IMF and WB, has been to increase privatization and FDI in India, at the same time leading to closing down of domestic industries, and laying-off of workers, unable to compete with the much greater competitive powers of the MNCs, and the flooding of the domestic supermarkets with foreign goods.

- In the present phase of a ‘global economy’, goods and services are produced and marketed by an oligopolistic web of global corporate network (MNCs), whose operations span national boundaries, but are only loosely regulated by nation-states; this paradigmatic shift has been made possible by the IT revolution.

- The concept of globalisation involves the blending of the global with the local; it is a strategy adopted by MNCs while dealing with local traditions in order to enhance their marketability.

- According to some, globalisation is a process of increasing heterogeneity, shifting identities and multi-polarity.

### 8.2 Internationalisation of Higher Education

Internationalisation of Higher Education is described as:

- “the complex of processes that gives universities an international dimension”; thus internationalization encompasses all facets of university life, including scholarship, teaching, research and institutional management.

- “the process which integrates an international or inter-cultural dimension into each of its three core activities, viz. teaching and learning, research and community service”.

- Includes academic mobility, global or multi-cultural education, area studies and study abroad,

- The rationales include: political rationales, such as peace and mutual understanding; as well as economic ones, such as the international labor market.

- Internationalisation is more a process than an activity with a beginning and an end.

- The rationales for internationalization are largely similar for both developed as well as developing countries.

- There appear to be four kinds of rationales for institutions of higher education, national governments, international bodies, and the private sector, to be actively involved in international educational activities: academic, social/cultural, political and economic.

- Internationality has come to mean the capability of equipping graduates with competencies applicable in a world where national borders no longer hinder the global flow of technologies and products. It is also the ability of academic communities to attract and integrate intelligence of any nationality seamlessly.

- The foreseeable effects of internationalization on engineering education and on its providers can be categorized into:
cooperation: organization of student and teacher mobility, mutual recognition of credits, development of a common system.

convergence: harmonization of the educational structures.

competition: struggle for motivated and qualified students and scientists.

Many policy makers consider the internationalization of the university and of the curriculum as the key components of internationalization.

An OECD study provides the following definition of Internationalised Curricula: “Curricula with an international orientation in content, aimed at preparing students for performing professionally and socially in an international and multicultural context, and designed for domestic students as well as foreign students.

What we had prior to the 1970s was an ‘international economy’ in which goods and services were traded across national boundaries by individual firms from different countries, under regulation by sovereign nation – states.

9. Quality and Accreditation Initiatives

The US National Science Foundation (NSF) Task Force on TQM has come up with the following definition of Quality Engineering Education:

“Quality Engineering Education is the development of intellectual skills and knowledge that will equip graduates to contribute to society through productive and satisfying engineering careers as innovators, decision-makers and leaders in the global economy of the twenty first century.”

The Task Force also points out that TQM is not a destination, but rather a journey to improvement.

There have been several discussions on the fundamental question whether Academic Quality is quantifiable. It is widely believed that academic quality, like beauty, for example, is an elusive characteristic.

Two Quotes are given below to bring out the need for quantification, and simultaneously the limitations of this approach.

Lord Kelvin: “When you can measure what you are speaking about, and express it in numbers, you know something about it; and when you cannot measure it in numbers, your knowledge is of a meager and unsatisfactory kind.”

G.N. Lewis: I have no patience with attempts to identify Science with measurements, which is but one of its tools, or with any definition which would exclude a Darwin, a Pasteur or a Kekule.

AICTE has set up a National Board of Accreditation for defining the criteria for assessment of Quality of Technical Institutions, both at the undergraduate as well as post-graduate levels. The Process includes: self-assessment by the Institution, as well as, an Expert Committee Visit, and subsequent consideration by a Sectorial Committee and the Board. It is gratifying that the necessity for Accreditation has been instrumental in making almost all the Institutions strive to put in place mechanisms for addressing Quality issues. The National Board of Accreditation is now making a proposal to the Washington Accord for Membership.

The Digital Divide refers to the gap between those who have access to information technology and those who do not and; the widening gap in both dial-up and broadband access. It is pointed out that to understand the Digital Divide, a much more sophisticated analysis is needed, one that looks beyond access to type and levels of use, acquisition of skills, and motivation to prepare for technology careers.

10.1 The Indian Scenario

Dr. Murli Manohar Joshi, Union Minister for HRD and S&T, has said: “The scientific knowledge of the future has to be one which is directly integrated with social requirement. Only such knowledge can help provide the foundations of a society, which becomes truly sustainable”. It is pointed out that technology itself is not relevant to mankind; the relevance lies in the human aspect of the technology. As far as IT tools are concerned, too much information paralyses action, and quality information is vital. New technology magnifies the gap between the information-rich and the information-poor. Joseph Dunite has said: ‘If we want the technology to liberate us rather than destroy us, we -- the techno peasants-- have to assume responsibility for it’.

While the Digital Divide is an issue of recent concern, the Technology Divide has been an issue for much longer. There appear to be two approaches to enable a wider population to benefit from the Technology and Information Revolutions: one is to enhance the level of literacy—basic, functional, technology and computer—and education among the population; and the other is to design ‘appropriate’ IT tools around the capabilities of the users, such as, for example, the Simputer, which employs audio/visual input/output (without the need to be literate).

11. The Importance of Partnership

The rationale for collaboration is highlighted by Henry Ford’s statement: “Coming together is a beginning; keeping together is progress; working together is successs”.

In order to derive the full benefits of Collaboration, it is necessary to identify and remove the barriers/inhibitors for Collaboration: Identify committed individuals (‘champions’) on either side, and empower them; enable potential partners to communicate with each other; accord recognition for collaborative work; put in place institutional mechanisms for promoting collaboration; identify collaborative partnership as a strategic intent.

11.1 The Case study of IIT Madras

A research university like IIT Madras enters into collaboration with a wide range of partners: other universities; industry; R & D labs; community organizations; government agencies; funding/sponsoring agencies; international agencies; and Alumni. IIT Madras has 36 MoUs (Memoranda of Understanding) with international universities. The activities include exchange of students and faculty members, undertaking joint projects, joint workshops, etc. Another interesting collaborative partnership involves three partners in the area of telecommunications: the faculty and research scholars undertake designs, the chips are manufactured by a company in the US, which are incorporated into the devices, which are prototype-manufactured and tested by companies started by alumni. The technology is transferred and licensed for manufacture by commercially-oriented companies.

12. Nurturing Alumni-Alma Mater Relationship

The strength of this Relationship is a function of: the success achieved by the Alumnus; the credit he/she is prepared to ascribe to the contributions of the Alma Mater; and the efforts made by each to
keep in touch with the other. The relationship itself is rather tenuous: such as that between Parents and Children, as they grow up. There are mutual expectations: the Alumni expect the Alma Mater to constantly keep in touch with them; communicate with them; continuously enhance its reputation so that the Alumni can be proud of their Alma Mater; and keep the feel-good factor at a peak all the time. The Alma Mater, in return, expects the Alumni to feel proud and good about the contributions of the Alma Mater in providing a good foundation and initial conditions as the basis of their present success; constantly keep in touch with it; promote activities that will benefit the Institute, in both tangible as well as intangible ways; form cohesive groups in the cities they live in, and help each other, if and when necessary; and provide mentoring and counseling to current students.

There are barriers however, such as for example: time constraints; time for self and family versus Alumni activities; apathy/cynicism, in some cases; lack of communication; and history of some bad experiences. Strategies to overcome these barriers, like in any partnership are: to establish communication channels and continuously communicate and interact; to organize Reunions; Regular Meetings, Chat Sessions and e-groups; Nodal persons to provide a focus; to promote mutual understanding and respect; to clearly articulate goals and projected activities; to elicit feedback back to reorient or fine tune plans; to ensure fast and precise response; to broadbase the participation; to provide leadership; to involve current faculty and students; to document success stories; and to learn from best practices of others.

It is Nostalgia that provides the strong force that binds Alumni with the Alma Mater. The intensity of Nostalgia is a function of space and time: it is directly proportional to the distance between the current location of the Alumnus and the Alma Mater; and it is directly proportional to the number of years elapsed since graduation.

13. Some Recommendations of a recent ATN-IITs Conference

An interesting Conference was held at Indian Institute of Technology – Madras a couple of years ago, with the participation of the Presidents of the Institutions comprising the Australian Technology Network and the Directors of five Indian Institutes of Technology. The principal objectives of the conference were to first learn of each other’s activities, strengths and interests, and to explore ways and means of promoting collaboration between the two “networks” of technical institutions.

The recommendations of this Conference are given under two heads:

I. Short-term action to cement the Collaboration and create impact and visibility:

- Opportunities for Indian students to undergo Summer Training in Australian Industries/Research Labs/ATN Universities; and for Australian Students to undergo Training/Research in Indian Industries/ R & D Labs/IITs.
- Preparation of R&D proposals in areas of mutual interest for funding by International/Bilateral agencies or industries through communication between interested faculty in the two systems. It would be advisable if more than one Institution from each side would participate in these ventures. Some examples are listed below:
  - Aerospace Technologies; Biomedical Technologies; Distributed Computing; Educational Technology; Energy and Environment Technologies; Engineering Education; IT and Telecommunications; Manufacturing Technologies; Materials Technology; Ocean Engineering; Strategic Planning and Management; Sustainable Development; Sustainable Energy Technologies; Transportation Engineering; Water Resources Management; Waste Water Management.
- International Conferences, on a relevant topic involving all the IITs and the ATN Universities.
Exchange of information regarding best practices and innovative initiatives with regard to Education, Technology and Management.

Joint collaborative teaching of courses, at the UG and PG levels.

Sharing of Courseware (in different media).

II. Possibilities of Long-term Collaboration

Exchange of UG, PG and Research students; Exchange of faculty for Teaching, Research and Consultancy; Exchange of support staff for Training, Consultancy, Technology Development; Collaborative Research, Technology Development, Industrial Consultancy, Educational Consultancy, Training Programmes for International clients - in Australia, India or other countries - on self-supporting basis; Joint International Conferences, Seminars, Workshops, Continuing Education Programmes; “2+2” initiatives (Industry + Institution in each country coming together as partners); Twinning Programmes possibility; Formal and Non-formal Programmes in 3rd countries through Distance Plus Contact Mode; Continuous exchange of information about new initiatives and feedback thereon; Establishment of Chairs in Australia and in India to facilitate exchange of Professors.

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## A SWOT ANALYSIS OF THE NATIONAL TECHNOLOGY EDUCATION SYSTEM

<table>
<thead>
<tr>
<th>STRENGTHS</th>
<th>WEAKNESSES</th>
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<tbody>
<tr>
<td>❖ Aspirations of our Youth to pursue Technical Education.</td>
<td>❖ Technical Education perceived as a Business opportunity by some.</td>
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<td>❖ Private Sector initiatives complementing Government initiatives.</td>
<td>❖ Severe shortage of qualified and competent faculty especially in (hi-tech) ICT.</td>
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<tr>
<td>❖ Increasing interest of Industry Associations (such as CII, FICCI, ASSOCHAM) and of Professional Societies to partner and collaborate with academic institutions.</td>
<td>❖ While there are islands of excellence these are rather few in number.</td>
</tr>
<tr>
<td>❖ The Accreditation initiatives of NBA are serving to promote Quality Improvement in the Technical Education sector.</td>
<td>❖ Lack of interest among graduating engineers to pursue teaching careers.</td>
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<tr>
<td>❖ The upcoming World Bank project will provide the necessary resources for upgradation of technical education in the country.</td>
<td>❖ Lack of interest for pursuing research degree programs.</td>
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<tr>
<td>❖ The QIP schemes have contributed significantly to the upgrading of qualifications of faculty in Technical institutions. The scheme has recently been enlarged to cover non-engineering disciplines also.</td>
<td>❖ Lack of availability of Ph.Ds in Engineering for faculty positions.</td>
</tr>
<tr>
<td>❖ The MODROBS, TAPTEC and R&amp;D schemes of AICTE, as well as of MHRD, have served to modernize the infrastructure and remove obsolescence, promote work on thrust areas, and R&amp;D programs in Technical Institutions.</td>
<td>❖ Lack of adequate industry-institute interaction.</td>
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<td>❖ Technical Education perceived as a Business opportunity by some.</td>
<td>❖ Mismatch between education and training (knowledge and skills) received by graduates, and job requirements.</td>
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<td>❖ Severe shortage of qualified and competent faculty especially in (hi-tech) ICT.</td>
<td>❖ Inadequate manpower needs assessment and manpower planning.</td>
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<tr>
<td>❖ While there are islands of excellence these are rather few in number.</td>
<td>❖ The widely prevalent affiliating system in our universities precludes timely curriculum updating and introduction of innovative reforms.</td>
</tr>
<tr>
<td>❖ Lack of interest among graduating engineers to pursue teaching careers.</td>
<td>❖ The recent boom in IT industry caused a disproportionate increase in admission capacity in this area, at the expense of other disciplines.</td>
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<tr>
<td>❖ Lack of interest for pursuing research degree programs.</td>
<td>❖ While the admission capacity at the UG degree level has been on the rise, a corresponding growth at the PG level has not taken place.</td>
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<td>❖ Lack of availability of Ph.Ds in Engineering for faculty positions.</td>
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A SWOT ANALYSIS OF THE NATIONAL TECHNOLOGY EDUCATION SYSTEM

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<th>OPPORTUNITIES</th>
<th>THREATS</th>
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<td>❖ For setting up quality Indian institutions --sponsored off-shore campuses.</td>
<td>❖ In the emerging GATS scenario, Quality concerns need to be addressed urgently.</td>
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<tr>
<td>❖ IT tools are becoming available for Technology-Enhanced Learning, for widening the reach of Technical Education.</td>
<td>❖ Competition from international players.</td>
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<tr>
<td>❖ Distance Education possibilities for Continuing Education.</td>
<td>❖ The non-uniformity in the distribution of Technical Institutions in the country, causing regional imbalances, and inter-state migration of students.</td>
</tr>
<tr>
<td>❖ Networking of technical institutions, at different levels, for mutual benefit, sharing of resources, undertaking major projects.</td>
<td>❖ The Technical Institutions in the rural and industrially-backward areas are not as popular with students, leading to unfilled capacity in these institutions.</td>
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<tr>
<td>❖ Networking of technical institutions with R&amp;D labs and industry.</td>
<td>❖ The tendency of our students to prefer IT-related courses, and to shun other disciplines.</td>
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<tr>
<td>❖ Schemes such as TDB, CORE, promoting industry-institute interaction.</td>
<td>❖ The tendency of research scholars to prefer computer-based research over experimental research.</td>
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<tr>
<td>❖ Many alumni are offering substantial support to their Alma Maters.</td>
<td>❖ The ration of diploma programmes to degree programs is on the decline (much unlike other countries.)</td>
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<tr>
<td>❖ The role of Technology and Technology Education for national development and prosperity is widely acknowledged.</td>
<td>❖ The Science-base in the country is getting weaker, which will have an adverse impact on our capacity for technology development.</td>
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SWOT ANALYSIS OF A TRADITIONAL ENGINEER

**STRENGTHS**
- Analytical Capabilities
- Design Capabilities—
  - ability to handle open-ended problems
  - ability to handle poorly-defined problems
  - creativity and innovation
- Decision-making, including problem solving
- Graphical communication skills
- Discipline, work ethic.

**WEAKNESSES**
- Inability to work in a Team
- Inter-disciplinary knowledge
- Practical orientation (academics)
- Commercial orientation
- Introspective nature, modesty
- Oral and written communication skills
- Integrative skills
- Ability to employ IT
- Obsolescence (remedy: Continuing Education)
- Inter-personal skills
- Public perception and recognition

**OPPORTUNITIES**
- Most real-life problems require contributions from Engineers
- National policies recognize role of S & T
- Business recognizes role of Technology
- Ambition of bright youth to become Engineers.
- Globalisation offers opportunities for acquisition of state-of-the art technologies.

**THREATS**
- Competition from Scientist, Economists, Financial Experts, Administrators in high-level decision-making bodies.
- Quantitative expansion in Technical Education without simultaneous Quality assurance
- Industrial development entails depletion of natural resources and environment degradation – Engineers are held are responsible for these.

Table III

THE DESIRABLE CHARACTERISTICS OF XXI CENTURY ENGINEERS

**TRADITIONAL ATTRIBUTES**
- Problem-solving abilities
- Analytical skills
- Communication skills—
  - oral, written, graphic
- Ability to relate to practical aspects of Engineering.
- Inter-personal skills.
- Management skills
- Decision-making skills.

**XXI CENTURY ATTRIBUTES**
- Learnability : learning to learn, on one’s own
- Ability to muster knowledge from neighbouring disciplines.
- Ability to work in a team.
- Exposure to commercial disciplines.
- Creativity and Innovation.
- Integrative skills.
Table IV

STAKEHOLDER RELATIONSHIPS
IN THE ENGINEERING EDUCATION SYSTEM

STAKEHOLDER → PROCESS → VALUE ADDITION

Student
- Manpower Development (Education, Training)
  → Engineering Professionals
  → Manpower Development
  → Competent Workforce
  → Technologies, Products, Processes
  → Up to date Workforce
  → Technology Solutions

Employees (Faculty, Staff)
- Employment Career Development
  → Livelihood, Prosperity
  → Tangible / Intangible Support
  → Competent Workforce
  → Technologies, Products, Processes
  → Up to date Workforce
  → Technology Solutions

Alumni
- Communication
  → Social and Economic Development

Industry
- R&D
- CEP
- Consultancy

Government
- Manpower Development R&D
- Industrial and Economic Development

Society
- Manpower Development R&D
- Social and Economic Development