THE EVOLUTION OF POSTGRADUATE ENGINEERING EDUCATION AND RESEARCH IN INDIA

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International Conference : Challenges to Innovation in Graduate Education, Toronto, November 2-5, 2005

SCOPE OF PRESENTATION

- The National Postgraduate Engineering Education and Research System.
- A Taxonomy of Graduate Education and Research Programs.
- Pertinent Statistics.
- Periodic Reviews of Postgraduate Education and Research in Engineering and Technology.
- The Nature and Scope of the University R&D System.
- Some Initiatives for Promotion of Innovation in Academic Institutions.
- Quality Improvement of Engineering Institutions.
- Other Issues of Relevance and Significance.
- Concluding Remarks.

1. THE NATIONAL POSTGRADUATE ENGINEERING EDUCATION AND RESEARCH SYSTEM

- **The National PG Engineering Education and Research System comprises:**
  - **7 IITs: designated as Institutions of National Importance.**
  - **5 deemed-to-be-universities.**
  - **18 National Institutes of Technology, distributed country-wide.**
  - **Other technical institutions in the Central sector.**
  - **Technical institutions in the States sector.**
  - **Technical Institutions/ Deemed Universities in the private sector.**

1.1 The IIT System

- IIT Kharagpur (1950) -- UNESCO support
- IIT Bombay (1958) -- USSR support
- IIT Kanpur (1960) -- US support
- IIT Madras (1959) -- FRG support
- IIT Delhi (1961) -- UK support
- IIT Guwahati (1995)
- IIT Roorkee (2001) -- UOR re-designated

1.2 The NIT System

- 17 Regional Engineering Colleges (RECs), were established one in each state, as joint and cooperative enterprises of the Central and the relevant State Governments, beginning from 1959.
- Recently, RECs have been re-christened as NITs.
- Very recently, Bihar Engineering College, Patna has been added to the NIT family, making up a total of 18.

2. A Taxonomy of Graduate Education and Research Programs

- **2.1 The 2-year M.E./ M.Tech. Programs**
  - **Majority of PG programs in the country.**

- **2.2 The Dual Degree (B.Tech./ M.Tech.) Programs**
  - **Introduced by 5 IITs**
  - **Admission through JEE (Joint Entrance Exam)**
  - **5 years' duration**
  - **Both degrees awarded at the end of 5 years .**

2.3 Some Special M.Tech. Programs

- On the basis of the existing strengths of the institutions and an assessment of the potential user needs.
- M.Tech. in Industrial Mathematics and Scientific Computing in the Dept. of Mathematics at IIT Madras;
  curriculum designed in consultation with the European Consortium for Mathematics in Industry (ECMI).
- A 3-year Master's Program in Medical Science and Technology (MMST) Program at IIT Kharagpur.
- User-oriented programs, such as:
  - M.Tech. in Construction Technology and Management at IIT Delhi and IIT Madras.
  - M.Tech. in Automotive Engine Technology @ IIT Madras.
  - M.Tech. in Software Engineering at IIT Madras.

2.4 The M.S. Research Degree Programs

- **Introduced by the IITs many years ago.**
- **Particularly beneficial to the many Project Associates, who are recruited under several sponsored projects, to register for these programs on part-time basis.**
- **IIT Madras also offers M.S. in Entrepreneurship and Management.**

2.5 The Pathways to PG and Research Programs in IITs

- **M.Tech. Programs**
  - Admission through GATE
  - Direct admission to children of NRIs on the basis of specified admission criteria.
  - Admission to Officers from Defence Services, based on common selection through interviews.
  - Admission to Faculty through the QIP.
  - Admission to candidates serving in the Industry, sponsored by their employers.
  - Admission for select group of students under various ‘user-oriented’ M.Tech. programs

3. Pertinent Statistics

Two components of the Engineering Education System:

❖ **The AICTE System**

- **The number of recognized institutions offering M.E./M.Tech. was just 6 prior to 1947; had increased to 321 in 2003, offering 1552 PG programs in hard-core engineering, with a total sanctioned intake of over 26,000 candidates.**
- **The annual out-turn, however, is just around 8000 (amounting to only 30% of the intake)**

- **Temporal growth:**

	1998 – 99	2002 – 03
No. of PG institutions	185	321
No. of PG courses	1138	1552
Sanctioned intake	9,491	26,169

3. Pertinent Statistics (cont'd)

❖ **The IIT System**

- **Overall student statistics for all IITs for 2002-03:**

	UG	PG	Ph.D.	Total
❖ Intake	2455	5437	973	8865
❖ Output	2274	3675	444	6393

(Note: PG output > UG output.)

❖ **53% of UGs secure campus recruitment, compared to only 30% of PG and Ph.D.**

❖ **A higher percentage of UG (about 30% on the average, but highly discipline-dependent) goes abroad (mainly for higher studies) than PG and Ph.D.**

❖ **The drop-out in Ph.D. programs is quite large.**

4. Periodic Reviews of PG Education and Research in Engineering and Technology

❑ 4.1 Thacker Committee (1959-1961)

Major Findings and Recommendations:

- ❖ **PG Education should have two distinct objectives:**
  - **Immediate objective: to produce specialists in a narrow field for immediate application of their advanced knowledge to industrial operations relating to design, construction, manufacturing, etc.**
  - **Long-range objective: to prepare for doctoral and industrial research.**
- ❖ **In order to attract candidates of high merit, scholarship should be provided to PG students.**

4.2 Appraisal of L.S.Chandrakanth (1971)

- **The P.G. curricula should be revised:**
  - **Decreasing the over-emphasis on theory**
  - **Increasing the emphasis on lab and project work**
  - **Providing a design or research orientation.**
- **Periodic reviews of PG programs should be undertaken, taking into account the needs of industry.**
- **Institutions must be given the freedom to initiate new programs.**

4.3 Nayudamma Committee (1978-1980)

- **The national investments in S&T education and research should increase many-fold to achieve the desired objectives.**
- **While the performance of a handful of institutions has been good, the majority of institutions has not performed well.**
- **For a variety of reasons, it has not been possible to attract sufficient numbers of bright students to PG education and research.**

4.3 Nayudamma Committee (1978-1980) – (cont'd)

- In order to ensure that only bright and motivated persons are admitted to PG programs, admissions should be made through a GATE.
- All existing PG programs which are outdated, stereotyped or unpopular should be wound up.
- All M.E./ M.Tech. programs should be of three semesters duration: 2 semesters of course work and one semester of dissertation work.
- Under no circumstances should further proliferation of existing programs in conventional or irrelevant areas be permitted.

4.4 Analysis and Follow-up of the three Reviews

- The PG degree was recommended to be the minimum qualification for recruitment to most positions in the industry and in the strategic sectors.
- For a variety of reasons, the brightest students were attracted to the private sector industry, study and research programs abroad, management schools, etc., and only the rest opted for PG education.
- The Nayudamma Committee considered its most important recommendation to be the requirement that evaluation and accreditation of PG courses should be performed at least once in 5 years by a suitable national agency.
- The recommendation to administer GATE for PG admissions has been implemented.

4.5 Rama Rao Committee (1995-1999)

- The recent explosive growth of the software industry and the emergence of management education provide lucrative job opportunities, and have caused the out-turn of PGs in engineering to be a mere one-third of the prevalent capacity (of over 19,000).

- There is a significant exodus of PGs in engineering disciplines to the IT sector.

4.5 Rama Rao Committee (1995-1999) – (cont'd)

- **Master's Degree Programs**

- **The duration of the Master's degree program should be enhanced to 21 months, in order to enable a good quality project to be completed.**

- **Well-endowed national S&T agencies, such as the Departments of Atomic Energy and Space, DRDO and CSIR should provide places for student projects.**

- **The scholarship for PG students was recommended to be enhanced, and reviewed periodically.**

4.5 Rama Rao Committee (1995-1999) – (cont'd)

- **Faculty Development**

- **In order to meet the current acute shortage of faculty, a wide array of steps should be taken:**

- **Early Faculty Induction Program (EFIP) to be introduced.**

- **Quality Improvement Program (QIP) to be enlarged and strengthened.**

- **Adjunct Faculty to be encouraged.**

4.5 Rama Rao Committee (1995-1999) – (cont'd)

- **Doctoral Programs and Advanced Research**

- **The output of Ph.D.s in engineering and technology is showing disturbing trends.**

- **The number of research publications is declining.**

- **With over 50% of Ph.D.s through QIP, the number of direct entrants to Ph.D. programs is abysmally low.**

4.5 Rama Rao Committee (1995-1999) – (cont'd)

- **The following steps were recommended to be urgently undertaken in order to improve the situation:**
- **<u>National Doctoral Program:</u>**
  to attract motivated and merited scholars;
  attractive fellowship and contingency grant; up to 50 per year.
- **<u>Schools of Advanced Graduate Study:</u>**
  to be encouraged to work in collaboration with national and international labs and research groups.
- **<u>Special Research Groups:</u>**
  to encourage faculty members, individually or in groups, to develop high-quality research programs in challenging and emerging areas.

4.5 Rama Rao Committee (1995-1999) – (cont'd)

- **Scholarships for Doctoral Students:**
  to be enhanced.

- **Vital Support Services:**
  - **A Manpower Information System (MIS) to be established.**
  - **A National Centre for Engineering Information to be established.**
  - **Networking of Libraries**
  - **Customization of Internet Educational and Technical Software.**

4.5 Rama Rao Committee (1995-1999) – (cont'd)

- **Funding Sources:**
  - **Government support to PG and Ph.D. programs has yielded returns of immeasurable worth, and hence should be continued.**
  - **Departments and Ministries other than MHRD, which have a stake in PG Education and Research, such as DST, Space, Atomic Energy, DRDO etc should also support and promote PG Education and Research.**
  - **In as much as Industry also has a stake in this area, it should support PG E&R in a substantial fashion.**

4.6 Analysis and Follow-up of the Rama Rao Committee Review

- The duration of the Master's degree programs has been enhanced to 4 semesters.
- The Scholarships / Fellowships for the Master's and Doctoral degree programs have been enhanced.
- The Master's programs have been brought under the purview of the NBA for the purpose of quality assurance and improvement
- The EFIP has been launched.
- The QIP has been broadened in scope, and strengthened quantitatively.
- The National Doctoral Fellowship Scheme has been launched.

4.7 The Review Committee on AICTE (2003)

- **Observations and Recommendations on PG Education and Doctoral Research:**
  - **The current output of Ph.D.s in engineering is just about 400, 80% of which are from the IITs, NITs and IISc; the number of Ph.D.s in Management, Architecture and Pharmacy is practically negligible.**
  - **The annual output of Ph.D.s should be doubled.**
  - **PG and doctoral education and research should be treated as a public good, and the government should be responsible for funding them.**

4.8 IIT Review Committee (2004)

- **The nomenclature of the degrees should be rationalised, both at the B.Tech. and M.Tech. levels.**

- **Three possible explanations are proposed for the PG intake being higher than the UG intake:**
  - **Expansion of UG intake is constrained due to shortage of physical infrastructure and faculty.**
  - **Increase in PG:UG ratio improves faculty research output.**
  - **Additional funds become available.**

5.3 Types of R&D pursued in India (7 types)

- **1.Basic Research**

- Intellectual pursuits about the nature of Nature.
- Questions about the ultimate structure of matter, or the origin of the universe.
- Opportunity to the greatest minds to work on important fundamental problems of their choice.
- Knowledge gained from basic research is the foundation upon which the structure of frontier, continuously evolving technologies (such as nuclear, space, bio-technologies) can be built.

5.3 Types of R&D pursued in India (7 types) – (cont'd)

- **2. Mission-oriented Applied Research and Technology Development**

- **Large, national missions related to the development of indigenous capability in high-technology fields, such as: nuclear power, missiles or satellites.**

- **Requires system integration of sub-systems based on a wide range of technologies and expertise in many science disciplines.**

5.3 Types of R&D pursued in India (7 types) – (cont'd)

- **3. Country-specific Applied Research**
- Relates directly to the national needs of our country, and are specific to the conditions prevailing here.
- Some of these projects could indeed be called Mission-oriented.
- Examples: Research
  - In the field of agriculture.
  - On diseases endemic to India.
  - On prediction of Indian monsoon.
- This kind of R&D addresses problems which may not interest the rest of the world, but is of highest priority to us.
  Ex.: The Green Revolution.

5.3 Types of R&D pursued in India (7 types) – (cont'd)

- **4. Industry-oriented R&D**

- **Contributing towards an 'economy based on modern technology'.**
- **National labs can act as an interface between the university system and the industry system.**
- **IPR issues are important.**
- **A number of industry associations also carry out research in specific industry areas, e.g. Textiles, Cement, Energy, Chemicals, Plastics, Automotive, etc.**

5.3 Types of R&D pursued in India (7 types) – (cont'd)

- **5. Parasitic Research**

- **Research, which appears to be important because it follows global trends, is pursued with excessive foreign contacts and collaboration, without original ideas coming from India, and tends to depend on foreign patronage.**

- **Benefits of such research, if at all, are likely to feed foreign technology, and the students trained in such areas tend to go abroad immediately after their Ph.D.**

- **Such parasitic research should be given low priority.**

- **While international scientific cooperation is important, India should not go for it on a 'donor-recipient' basis.**

5.3 Types of R&D pursued in India (7 types) – (cont'd)

- **6. Research for Teaching Improvement**
  - If a University Teacher is an excellent Researcher as well, it is indeed an ideal situation.

- **7. Direction-less Applied Research**
  - Applied research pursued indefinitely without linking up with an end-user. This seems to be entirely purposeless, and leads only to frustration in the group, followed by degradation of the knowledge developed after some time.
  - Such research should be abandoned if a suitable industrial or other end-user is not found in time.

6. Some Initiatives for Promotion of Innovation in Academic Institutions

- **6.1 Foundation for Innovation and Technology Transfer (FITT) at IIT Delhi**

- **Established as a Registered Society in 1992, with the mission: "To be an effective interface with the industry, to foster, promote and sustain commercialisation of S&T in the Institute for mutual benefits".**

- **Among the key terms of reference: "to add commercial value to academic knowledge and to market the intellectual and infrastructure resources of IIT Delhi for national development".**

6. Some Initiatives for Promotion of Innovation in Academic Institutions – (cont'd)

- **6.2 Society for Innovation and Development (SID) at the Indian Institute of Science**

- **Founded in 1999 with the mission: "to enable India's innovations in S&T by creating a purposeful and effective channel to help and assist industries and business establishments to compete and prosper in the face of global competition, turbulent market conditions and fast-moving technologies".**

- **It has a symbiotic relationship with IISc in an industry-friendly as well as a faculty-friendly way.**

7. Quality Improvement of Engineering Institutions

❑ 7.1 The Mission REACH Programs

- ❖ **Relevance and Excellence in ACHieving new heights in educational institutions.**
- ❖ **Launched by the Technology Information Forecasting and Assessment Council (TIFAC) in Oct. 2002 to create 80-100 Centres of Relevance and Excellence (COREs) under the broad umbrella of India Millennium Mission 2020.**
- ❖ **So far, 17 TIFAC- COREs have been established.**

7. Quality Improvement of Engineering Institutions – (cont'd)

- **7.2 A Special Initiative to upgrade select institutions into IITs**

- **As of now, about 200,000 aspirants compete in JEE for about 3000 seats in the 7 IITs.**

- **Much demand for more IITs : new ones as well as upgradation of existing good institutions.**

8. Other Issues of Relevance and Significance

8.1 Brain Drain Issues

- Brain Drain: more or less permanent migration of highly qualified and talented manpower from a developing country, in which it has been trained at considerable expense, to a developed country.
- Two types of factors have been identified to be the cause of brain drain:
  - "Push" factors: refer to the adverse conditions in the developing countries that provoke emigration.
  - "Pull" factors: refer to the favourable conditions in the developed countries that make immigration attractive.

8. Other Issues of Relevance and Significance – (cont'd)

- A few decades ago, the major brain drain was from the IITs, and of B.Techs, who went abroad for higher studies, mostly to US universities, and were able to secure financial assistance in the form of Teaching / Research Assistantships.

- Estimate: about 30% of B.Tech. output : varies IIT-wise, discipline-wise and year-wise.

- In recent years, there has been a considerable exodus from other colleges as well.

8. Other Issues of Relevance and Significance – (cont'd)

- **Very recently, the number of IIT B.Techs going to the US for higher studies has come down:**
  - **Attractive and challenging job opportunities at home**
  - **Visa difficulties**
  - **Attraction of MBA programs in the country ("internal" brain drain)**
  - **Outsourced work from developed countries.**

- **Evolution of Perceptions:**
  - **Brain "Drain" to: Brain "Gain" or "Bank": to Brain "Circulation".**

8. Other Issues of Relevance and Significance – (cont'd)

- **8.2 <u>Accreditation of M.Tech. Programs</u>**

- **NBA of AICTE is responsible for the accreditation of all Technical Education programs.**

- **Unlike in most other countries, including those subscribing to the Washington Accord, NBA also accredits M.Tech. programs.**

8. Other Issues of Relevance and Significance – (cont'd)

8.3 Internationalisation Issues

- **Internationalisation includes both 'import' and 'export' of education, and takes many forms:**

- **"Import":**
  - **Establishment of a campus by a foreign university.**
  - **Partnership with a local University / Institution for offering a joint program.**

8. Other Issues of Relevance and Significance – (cont'd)

- **"Export":**
  - **Establishment of a campus abroad.**
  - **Partnership with a foreign University / Institution.**

- **The regulatory framework has been established for entry and operation of foreign institutions in India.**

- **There is also a mechanism for establishing and granting equivalence and recognition of foreign degrees by The Association of Indian Universities.**

8. Other Issues of Relevance and Significance – (cont'd)

- **8.4 An Indo-German Student Exchange Program**

- **Initiative of the Indo-German Consultative Committee.**

- **M.Tech. students from the IIT system undertake their project work in 6 select German Universities, followed by brief industrial internships.**

- **Numbers: vary IIT-wise, discipline-wise and year-wise; approx. 15 from each IIT.**

- **Reverse flow of Ph.D. scholars from German universities.**

9. Concluding Remarks

- **The graduate education and research system in India has evolved over the years, and has made significant contributions to national development in industrial and strategic sectors.**

- **Several new initiatives are aimed at both quantitative expansion and qualitative improvement.**

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