cator, a pre-check name-check procedure. The primary security objectives of the MANTIS programme are:

'(1) To assist in the stemming of the proliferation of weapons of mass destruction and missile delivery systems; (2) To assist in the restraint of the development of destabilizing conventional military capabilities in certain regions of the world; (3) To assist in the prevention of the transfer of arms and sensitive dual-use items to terrorist states; and (4) To assist in the maintenance of US advantages in certain militarily critical technologies'.

The above Mantis-programme objectives are operated on a (to-be-revised) Technology Alert List (TAL), which reads:

a. Advanced ceramics: Technologies related to the production of tanks, military vehicles, and weapons systems.
b. Advanced computer/microelectronic technology: Technologies associated with superconductivity, supercomputing, microcomputer compensated crystal oscillators.
c. Aircraft and missile propulsion and vehicular systems: Technologies associated with liquid and solid-rocket propulsion systems, missile propulsion, rocket staging/separation mechanisms, aerospace thermal and high-performance structures.
d. Chemical and biotechnology engineering: Technologies associated with the development or production of biological and toxin agents, pathogenics, biological weapons research.
e. Conventional munitions: Technologies associated with warhead and large caliber projectiles, fusing and arming systems.
f. High-performance metals and alloys: Technologies associated with military applications.
g. Information security: Technologies associated with cryptographic systems to ensure secrecy of communications.
h. Lasers and directed energy systems: Technologies associated with laser-guided bombs, ranging devices, countering missiles.
i. Marine technology: Technology associated with submarines and deep submersible vessels, marine propulsion systems designed for undersea use and navigation, radar, acoustic/nonacoustic detection.
j. Materials technology: Technologies related to the production of composite materials for structural functions in aircraft, spacecraft, undersea vehicles and missiles.
k. Missile/missile technology: Technologies associated with air vehicles and unmanned missile systems.
l. Navigation and guidance control: Technologies associated with the delivery and accuracy of unguided and guided weapons, such as tracking and homing devices, internal navigation systems, vehicle and flight control systems.
m. Nuclear technology: Technologies associated with the production and use of nuclear material for military applications.
n. Remote imaging and reconnaissance: Technologies associated with military reconnaissance efforts, such as drones, remotely piloted or unmanned vehicles, imagery systems, high resolution cameras.
o. Robotics: Technologies associated with artificial intelligence, computer-controlled machine tools.
p. Sensors: Technology associated with marine acoustics, missile launch calibration, night vision devices, high-speed photographic equipment.

US consular officers have been asked to 'bear in mind that while the TAL is a valuable tool for recognizing possible illegal technology transfer, it is not an exclusive mechanism for identifying such cases'. Where the consular officer has reason to believe that an applicant may fall within the suspect zone despite the applicant having no direct connection with a scientific or technical field included on the TAL, the officer must submit such cases for security advisory opinions to the US State Department using the 'VISAS DONKEY MANTIS' code indicator.

Visa-issuing US consulates are required compulsorily to use the VISAS MANTIS procedure to process non-immigrant visa cases. But there is a fast-track VISAS EAGLE MANTIS procedure for nationals of the People's Republic of China, and of Russia applying for visas in those countries. But there is no such fast-track for Indians applying for US visas in India. So much for the 'burgeoning relationship!'

Slow pace of engineering education reforms

Projected demand for scientists and engineers: Are we clueless as much as dataless?

India is concerned about adequacy of its numbers of scientists and engineers, just as is being felt right across the globe. Elsewhere, strategies in policies and programmes are being reinvestigated constantly and measures taken to balance supply and demand. This requires a piggyback on some kind of science and engineering indicators that are dynamically evolving at a regular frequency. In India, however, present statistics which are relied upon are those in the form of outdated Government indicators such as the 1995–96 data of the Department of Science and Technology, published in 1999, or from borrowed foreign data that are mostly inadequate in nuances of 'India specific indicators'. There is presently no Government independent statistics available off the shelf for science and technology with a 'made in India' label.

Now in 2003, a move is on for changing this scenario, according to M. S. Valiathan, President of the Indian National Science Academy (INSA), New Delhi. INSA has begun an initiative for bringing out at the end of 2004, an India Science Report, a kind of ready-reckoner on science and technology statistics[1]. This would help inject the right momentum for altering business models suitable for the contemporary and competitive environment that we live in today, with updates of the expected report planned at regular intervals.

How many engineers produced?

According to the National Science Foundation (NSF), United States of America employment opportunities in science and engineering (S&E) would place a demand for about 2.2 million jobs by 2010, with over 80% predicted in computer and related areas[2]. It states that the employment for all engineering occupations is likely to increase by less than 10% by 2010, with environmental engineering requiring at least 27% of estimated jobs. It further states that in 1999, 13 million people had S&E education with 3.5 million employed in S&E professions. Engineers accounted for 1.37 million of the S&E jobs. Of the 3.5 million, 56% had a bachelor's degree, 29% a Master's and 14% a doctorate degree. Nearly two million of the 13 million were in the process of finding employment or unemployed.

Some Asian countries such as Japan, South Korea, Singapore are faced with gaps in supply and demand, having to remake policies for attracting talent, i.e. higher pay scales and better research environments. China and India help the United States in providing an immigrant workforce to fill gaps in the US demand for skilled people and soon other Asian countries would do likewise. Data for Doctoral Engineering Degree holders in some Asian and industrialized countries are given in Table 1. India, with a billion people, shows a dismal performance since Independence of producing doctorates in Engineering which stood at just 298 in 1998. Gangan Prathap has recently highlighted these data[3]. A comparative chart of Indian Science and Engineering Ph Ds produced between 1954 and 1996 is shown in Table 2.

Indian engineers and their education

A country's development and competitiveness is hinged on engineers, as much true for India, making 'quality and relevant engineering education' extremely vital. So, is the present status of technical education constantly evolving for meeting changing requirements and being responsive to India's developmental challenges? Has the engineering curriculum kept pace or has it distanced itself from India's needs for a competitive advantage, devoid of design skills, knowledge of basic sciences and ground realities of industrial problems? Has it paid attention to instrumentation, materials technology, defence R&D, infrastructure development such as roads, bridges, etc., value-added food processing or even converting traditional crafts into cutting edge crafts with the induction of new processes in materials technology. Is engineering education, as it exists today relevant and fully equipped to understand emerging developments in cutting-edge frontier areas of scientific research? Why do we not see in-house corporations emerging from universities and engineering colleges that incubate applied aspects of scientific and engineering research on a pilot-plant scale? Or, is much of the research in top-notch engineering institutes oriented mostly to 'foreign dictated problems' that have little relevance to building India whilst smaller engineering colleges languish with paucity of infrastructure and quality teachers?

Observations made by Indian National Academy of Engineering (INAE) Fellows

The following observations were made in December 2002 showing that presently we still continue to be shackled by an inability to speed up reforms in Engineering Education.

- Engineering entrants to industry have no idea of applications to industry problems. The M Tech. course should have components of practicals, managerial, industry-related projects and Ph D thesis oriented to real-life industrial problems.
- Mission approach to revamp system, curriculum and focus of projects – industry could help with funding support.
- Increase research in R&D applications and increase number of doctorates in engineering.
- Reorient curricula in conventional engineering to accommodate new applications for example space remote sensing, Geographic Information Systems, IT-enabled CAD tools, Management Information Systems, etc.
- Need a cadre of Indian Engineering for running various organizations like the Public Works Department, etc. and for taking informed decisions on topics such as rural roads, connectivity, urban sanitary systems, etc.
- Involve more private industries in infrastructure development.
- Introduce one module in institutions highlighting Indian engineering success stories.
- Inability to design is cited as a weak point among Indian engineers.
- Labour policies that could weed out the bottom four per cent, making way for fresh inputs each year.
- Making a band of skilled 'industry user friendly' diploma holders.
- Regional imbalance in Engineering colleges especially for the Northeast Region.

Reshaping engineering education

In an attempt to reshape engineering education in the country there have been two previous Reports on Engineering Education, one by M. S. Thacker (1959–61)

Table 1. Number of doctoral engineering degree holders in selected countries [Source: ref. 2]

	1998
Asian countries	
China	2900
India	298
Japan	3580
South Korea	1393
Taiwan	477
Industrialized countries	
France	1852
Germany	2100
United Kingdom	1837
United States	5930

Table 2. Comparative chart of science and engineering Ph Ds produced in India between 1954 and 1996. [Source: ref. 4]

Year	No. of Ph Ds in science	No. of Ph Ds in engineering
1954	164	19
1956	210	23
1958	216	27
1960	361	38
1964	537	47
1966	776	94
1968	1101	181
1970	1212	247
1974	1515	266
1975	1484	445
1978	2044	319
1979	2262	506
1984	2977	464
1985	2838	559
1986	2814	603
1987	3038	675
1988	3038	573
1989	3044	560
1991	2950	629
1992	3386	323
1993	3505	348
1994	3467	329
1995	3657	337
1996	3861	374

and another by Y. Nayudamma (1978–80). Instead of a dynamically evolving mechanism to look at trends and developments, it was again only in 1999 that the next Report was published. This All India Council of Technical Education (AICTE) Report wrote that a review of the recruitment pattern suggests that even after nearly two decades, the Nayudamma Committee recommendation on the crucial issue has not widely come into vogue. This recommendation had read, 'It is necessary to recognize publicly and publicize widely that, in today's world, Post Graduate (PG) studies at the Master's degree level are a normal part of basic engineering education. It should be made mandatory to prescribe a PG degree as the minimum qualification in recruitment to many positions in industry, R&D organizations, electricity boards, public works department, post and telegraph, railways, etc.'

Several stalwarts of Indian science and engineering were members of the PG Review Committee headed by P. Rama Rao[4]. The Committee constituted in September 1995, submitted its Report in 1999 and subsequently in 2001 the Ministry of Human Resource and Development (MHRD) mooted its 'policy framework'. The chapter on 'Appraisal of present state of PG education and research programmes' spells out persisting problematic unresolved issues such as the following:

- Present 18-month Master's programme is insufficient for training students to serve R&D needs of India and suggests a 21-month course duration.
- Dropout rate in IITs and IISc is below 10% whereas elsewhere this varies from 25 to 40%, mostly due to Civil Service aspirants and the Report suggests flexibility.
- Two semester PG diploma programmes are not industry-specific and are archaic in their approach to providing skills for industry operations that have rapidly changed.
- Out-dated PG courses that need to have a closure clause if no longer relevant.
- Flexible downsizing of courses that leave seats vacant while increasing those that are in demand.
- Disturbing trends in out-turn of Ph Ds in engineering that stood at 374 in 1996 compared to 3861 Ph Ds in science. The Report further notes that of these, over 50% is as a result of Quality Improvement Programme giving a very low figure for direct entrants.
- Acute shortage of teachers in engineering colleges with nearly 30% positions remaining unfilled both for Undergraduate and PG programmes.
- PG courses have heavy content of theory with very little on experiment.

The Report crucially calls for an increase in the number of engineering Ph Ds for ' original research and competence building', especially in view of the fact that 'Composition of our exports, i.e. items resulting from indigenous R&D were not amounting to even 10%'. Table 3 gives the number of Ph Ds in engineering awarded by major institutions during 1992–1995 (source: ref. 4). The region-wise number of Engineering Colleges approved up to 1998–90 and Sanctioned Intake capacity (as on 21 January 1999) are shown in Table 4 (source: ref. 4).

Financial requirements for implementing the recommendations of the Report are about Rs 245 crore rupees over a period of five years. The Report further adds that this does not include additional financial expenditure on account of starting new PG programmes, enhanced fellowships for ME/M Tech and Ph D students, additional maintenance grant to public-funded institutions running Masters and PG Diploma courses, for which a further Rs 55 crores is envisaged.

MHRD moots policy framework

In a letter dated 20 December 2001, the MHRD stated that it is pleased to lay down a 'Policy Framework for Promotion of PG Education and Research in Engineering and Technology, in the country after careful consideration of the above AICTE Report. Some new changes in this policy framework are:

PG programmes

- Duration of M Tech to be increased from 18 to 24 months to strengthen project work with a possibility for those who discontinue to return within five years.
- Graduate Aptitude Test in Engineering (GATE) examination to be continued and National Co-ordination Board of GATE would function for three years at a time. Self-financing students would be encouraged for admission in branches with greater demand.
- M Tech scholarships would be raised from Rs 2500 to Rs 5000 per month.
- Out-turn of students with PG degree in engineering to be doubled in 6 years.
- One-year PG Diploma programmes in specialized areas and IT-based distance education.
- Greater focus on course content and choice of new and emerging areas with the help of an AICTE standing committee reviewing every three years.
- An average turnout of less than 40% of the sanctioned strength would mean closure of the PG programme.
- Accreditation as a tool for quality management.
- Concept of 'Technology Entrepreneur' would be encouraged.
- Kishor Vigyan Protsahan Yojana (KVPY) scholars would have facilities to pursue education to PG level.

Table 3. Number of Ph D in engineering awarded by major institutions during 1992–1995. [Source: ref. 4]

Category	Institution	Total
I	IISc Bangalore	65
	IIT Bombay	169
	IIT Delhi	140
	IIT Kanpur	75
	IIT Kharagpur	128
	IIT Madras	220
II	AMU Aligarh	4
	Anna University	41
	BHU Varanasi	66
	BITS Pilani	9
	Jadavpur University	36
	MS Univ. Baroda	4
	Univ. of Roorkee	62
	UDCT Bombay	65
III	REC Allahabad	4
	REC Bhopal	8
	REC Jaipur	4
	REC Kurukshetra	6
	REC Rourkela	3
	REC Srinagar	12
IV	PSG Coimbatore	14
	SGSITS Indore	10
	VJTI	4
Total		1149

IIT Kharagpur has produced during 1992–95, 100 Ph Ds in the following disciplines: Agriculture and Food Engg and Management, Geophysics and Geology, Rubber Technology, Architecture and Regional Planning. This number has not been included.

- M Tech scholarship to be raised from Rs 6000 to Rs 7000 per month and for B Tech to Rs 6000 with an increment of Rs 500 per annum.

Doctoral programmes

- Fifty National Fellowships with a scholarship of Rs 12,000 per month and a contigency grant of Rs 25,000 per annum.
- Twenty special research groups in emerging areas with financial support for five years and then on, self-supporting.
- All Ph D scholars to do around 8 hours teaching with Teaching and Research Assistantships.
- Considerable flexibility for those in industry for pursuing doctoral research.

Faculty development

- Early Faculty Induction Programme and Quality Improvement Programme to be expanded.
- Adjunct faculty for sharing expertise with industry.
- Present system of Government funding to continue. A long overdue mechanism of partnership between socio-economic Ministries such as Power, Petroleum, Coal, Steel and Mines for encouraging PG education would be evolved.

The AICTE Report of 1999 had cited one crucial recommendation made by an earlier Committee that had not been implemented. The Nayudamma Committee had recommended that a reliable Manpower Information System for storage, retrieval, updating and analysis of manpower information should be established to assist technical education planning. Also a recommendation that doctorate degree was a pre-requisite for PG teaching and making a PG qualification mandatory for recruitment to many positions in the engineering profession.

The changes and other recommendations made by the MHRD in 2001 are the following:

- Selected Departments or interdisciplinary schools as Schools of Advanced Graduate Study
- Lecturers with B Tech should acquire M Tech within five years and a Ph D within a stipulated time. Ph D should be a desirable qualification for teaching at PG level.
- National Technical Manpower Information System (NTMIS) funded by MHRD/AICTE to be expanded and strengthened as a comprehensive MIS for PG education and research.
- Encourage industry to support PG programmes or establishment of scientific infrastructure with tax rebates.
- Network of libraries with 20 nodal libraries and establishing a National Centre for Engineering Information.

A list of 35 new and emerging areas has been prepared which includes Biotechnology, Environmental Engineering, Energy Management, Remote Sensing, Sustainable Development Technology, Materials Technology, Nanotechnology, Polymer Technology, Food Process Engineering, Industrial Design, Biomedical Engineering and Integrated Rural Development.

Table 4. Regionwise number of engineering colleges approved up to 1998–90 and sanctioned intake capacity (as on 21 January 1999) [Source: ref. 4].

Region	States/ Union territories	Engineering and technology/ No. of institutions	Sanctioned intake
Central	Madhya Pradesh	30	5675
	Orissa	20	3795
East	Mizoram	–	–
	Sikkim	–	–
	West Bengal	19	3672
	Tripura	1	120
	Meghalaya	–	–
	Arunachal Pradesh	1	210
	Andaman and Nicobar	–	–
	Assam	3	660
	Manipur	1	150
	Nagaland	–	–
North	Bihar	12	2385
	Uttar Pradesh	51	9030
North West	Chandigarh	3	530
	Haryana	27	4695
	Jammu and Kashmir	8	1060
	New Delhi	6	1460
	Punjab	20	3810
	Rajasthan	11	2129
	Himachal Pradesh	2	350
South	Andhra Pradesh	88	20,285
	Pondicherry	2	540
	Tamil Nadu	129	32,160
South West	Karnataka	70	24,752
	Kerala	19	4860
West	Gujarat	20	4850
	Maharashtra	118	28,985
	Goa	2	330
	Daman and Diu	–	–

Ground realities

The World Bank has in its recent 'Engineering Technical Education Quality Improvement Program Project' in India aimed at a systematic transformation of the technical education sub-sector, into a dynamic, demand-driven system, responsive to rapid economic, and technological developments. But is this kind of approach enough or is a speedy transformation of urgently needed reforms in the technical education sector warranted?

With paucity of statistics, even in 2003, on engineering education and demand for engineers in various sectors, the oft-repeated observation that 'India has a large pool of scientific and engineering workforce' may not hold much water especially in relation to doctorates in engineering. Then the important aspects of 'requisite quality' and 'periodic up-skilling, due to shelf-life of emerging technologies being very short' have been so far not adequately addressed. Has the impact of the IT revolution on conventional areas of engineering been looked at? We are even deeply aware of the need for 'original thinking and innovation as a critical component for the Nation's development' but we see no perceptible change in any of our out-dated systems. Our multitude problems continue to bog us down in spite of all the podium speeches. As is often heard in 'top' circles, its no more a question of adequate resources, but that changes require focus, steadfast will and a clear mind. If funds are in plenty, then the glitch could be in funds not being directed quickly enough or the lackadaisical approach to their implementation. We better hurry before the rest of the world passes us by. The P. Rama Rao Report in its concluding remarks had hoped that 'its recommendations would come into force in August 1999 and India would be placed in a strong position to look forward to a technologically brightened future'. It is now crunch-time for the Indian Engineering fraternity to speak out aloud on the progress, or the lack of it.

1. Valiathan, M. S., *pers. commun.*
2. *Science and Engineering Indicators – 2002*, Division of Science Resource Statistics, National Science Foundation, Arlington, VA, USA (http://www.nsf.gov/).
3. Gangan Prathap, *Curr. Sci.*, 2002, **83**, 1056.
4. AICTE Report: 'Reshaping Postgraduate Education and Research in Engineering and Technology', 1999, All India Council for Technical Education, New Delhi.

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RESEARCH NEWS

A possible explanation for MACHOs: A candidate for dark matter – from quark–hadron phase transition

Debasish Majumdar

A possible constituent for Massive Astrophysical Compact Halo object or MACHO – a candidate for dark matter, has recently been proposed by Banerjee *et al.*[1]. Way back in 1933, Fritz Zwicky found that the mass that he could account for in stars and galaxies is only a small fraction of the mass needed to account for in stars and motion observed in Coma cluster. Over the years, from different observations, astronomers have found a similar discrepancy for other galaxy clusters, as well as for individual galaxies. These discrepancies led to the foundation of 'dark matter'; matter which cannot be observed directly and the evidence for dark matter is only gravitational.

Present consensus is that the visible matter constitutes only around 5–10% of the total matter of the universe, and the rest is in the form of dark matter. There may also be a large amount of energy in the form of dark energy to account for the accelerated expansion of the universe. The form of dark energy remains a total mystery even today, though it now seems from Banerjee *et al.*[1] that the cold dark matter can be explained in a natural way. While there may well be more than one type of dark matter, such as baryonic or non-baryonic, hot (relativistic) or cold (non-relativistic), large-scale structure calculations suggest that non-relativistic (cold) dark matter (CDM) constitutes a dominant fraction of dark matter.

Recently there has been experimental evidence of at least one form of dark matter, namely MACHOs in the halo of the Milky Way Galaxy. The light from a distant star, passing by a MACHO, bends due to the large gravitational field of the MACHO. The bending of light is a consequence of Einstein's General Theory of Relativity and is known as gravitational lensing. In the present case, since the lens is relatively small (compared to the galaxy), multiple images are not observed. On the other hand, due to relative motion between the stars and MACHOs, the lensing effect causes an increase in the brightness of that distant object. Using this phenomenon, known as gravitational microlensing, around 13–17 MACHOs have been detected in the Milky Way halo.

A definite candidate for MACHOs has been proposed by Banerjee *et al.*[1]. It is suggested that MACHOs have evolved out of the strange quark nuggets (SQNs) formed during the first-order phase transition of the early universe from quark phase to hadronic phase, at a temperature around 100 MeV (10^{-5} s after the Big Bang). During this phase transition, hadronic matter starts to appear as individual bubbles in quark–gluon phase[2,3]. With the progress in time, more bubbles appear and they expand to form a network of such bubbles (percolation) in which the quark matter gets trapped. With further cooling of the universe, these trapped domains of quark matter shrink rapidly without significant change of baryon number, and eventually evolve to SQNs through weak interactions with almost nuclear density[4]. These objects are stable and calculation shows that to explain all the CDM, the baryon number of an SQN should be ~ $10^{42–44}$ (ref. 5), assuming all SQNs to be of same size. These SQNs with masses ~ 10^{44} GeV and size ~ 1 m would have very small kinetic energy compared to their mutual gravitational potential.

Hence, gravitational collapse seems to be a natural fate. The only agent that can prevent a collapse is radiation pressure (protons and neutrinos). It has been shown that indeed the effect of radiation pressure remains quite substantial until it weakens below certain critical value due to the drop in the temperature of the ambient universe. At the time when gravitational force overcomes radiation pressure, it is found that for a MACHO of size 0.24 $M_\odot$ ($M_\odot$ is the solar mass) one would need 2.44×10^{14} SQNs each with baryon number 10^{42}. The total number of MACHOs in the Milky Way halo is ~ $10^{13–14}$ and the corresponding optical depth of these objects is shown to be com-