environmental-friendly patterns of resource use, and (v) design a system of positive incentives that would make local people willing partners in conservation efforts[3].

It is hoped that 'such a project would be the beginning of a wholly new open, bottoms-up process of conservation planning as well as of reorienting the educational system to involve teachers and students in real life problems pertaining to the local environment, that would hopefully slowly cover other parts of the country as well[3].

1. Gadgil, M., *Biodiversity: Tapping Folk Knowledge*, *The Hindu*, January 10, 1993.
2. Gadgil, M., Involving people. In Managing our Natural Resources, Seminar 406, 14–18
3 Gadgil, M., in *Conserving the biodiversity of the Western Ghats: a participatory approach*, private circulation, 1993.

COMMENTARY

Student–faculty ratio at IITs and its impact

Pankaj Jalote

Currently all the five Indian Institute of Technologys (IITs) together produce less than 1500 B.Techs. every year. A conservative estimate is that 40–50% of these go abroad for higher studies (and most never return), 10–20% go in management, and 5–10% go in civil and other services, leaving a mere 500–750 B.Techs. for doing engineering in industry! A specific example will highlight this point dramatically. The IITs produce about 200 B.Techs. *in computer science, out of* which at most 50–100 join the computer industry. Compare this with the projected demand of over 30,000 software professionals by 1995 in the country to meet its plan on growth in IT industry and software exports! IITs produce only about 2% of the total number of engineering graduates produced per year in the country (appx. 70,000)!.

It is clear that with the current numbers, IITs will not make any significant impact on trained manpower needs of the country and consequently on industry as a whole, particularly in this day when the country is liberalizing and is poised for a major industrial growth. This will lead to loss of importance and marginalization of IITs in the national perspective, which will have many undesirable effects on the IITs, including loss or reduction in funding (signs of which are already appearing). This report shows that the low student-faculty ratio (S/F ratio) is a central reason behind this, and the one clear way to maintain the preeminence of IITs is to *produce a much larger number of highly* qualified engineers to satisfy the demands of a growing economy, at a much lower cost

S/F ratio at IITs and comparison with USA

In an IIT, typically about 250 B.Tech.s (not counting students of sciences and maths) and 250 M.Tech.s are graduated each year. An IIT has of the order of about 200 engineering faculty (with a total of about 325 faculty). This means that only appx. 1.2 B.Tech. and 1.2 M.Tech. is graduated per year per (engineering) faculty! Or overall the S/F ratio at an IIT (including all B.Tech. and M.Tech. students) is only about 8, i.e. in an IIT there is 1 (engg.) faculty for every 8 (engg.) students!

One cannot compare these numbers with those existing in other universities in India or even other engineering colleges, as the nature of IITs and their focus is different. However, comparison with engineering institutions in USA definitely makes sense as IITs and these institutions have similar approach to education and R&D. To put the output of IITs in perspective, a survey was conducted of some of the major state universities in US. The name of the university, size of the engineering faculty, number of engineering graduates each year, *and number of engineering Masters* per year is given in the table

As can be seen from this table, on an average 3.5 Bachelors and 1.4 Masters are graduated per year, per (engg.) faculty in these universities. And this is for the universities which are among the best state universities in USA offering a very high quality education Furthermore, these universities produce a higher number of students per faculty despite the fact that their primary focus is not on teaching – a major part of the faculty's time is spent in R&D activities and the R&D output of these universities is very high. These numbers are much higher in many other state universities, which place lesser emphasis on research than the universities listed above.

Need to increase output of IITs

In India there is a vast difference in the quality of education imparted at IITs (and similar institutions) and other engineering colleges. Undoubtedly, one of the primary factors for this difference is the high quality of the faculty IITs have been able to attract (most having Ph.D.s from prestigious institutions across the world). Furthermore, in India, unlike in the US, there is an acute shortage of well qualified faculty for engineering disciplines and perhaps the most critical resource today for engineering education is qualified faculty. Given the difference in quality of faculty, it is unlikely that other institutions can produce the high quality of engineers and technologists that IITs can produce. And new institutions cannot be started for this due to the shortage of well qualified faculty. Therefore, perhaps *the only way to increase the availability* of highly qualified engineers and technologists in the country is to dramatically increase the output of IITs.

Given this situation in the country, it is clear that IITs should be producing even more than the average production per faculty in the universities listed above. This will mean that each IIT should be graduating 4-5 B.Tech.s and 2–3 M.Tech.s per year per faculty That is,

University	No. of Engg. faculty	No. of Bachelors	No. of Masters
UC. Berkeley	230	590	375
Illnois, Urbana	350	1220	400
Wisconsin, Madison	225	620	220
Michigan, Ann-arbor	320	100	450
Georgia-Tech	300	1260	560
Maryland, College Park	175	650	250
Rutgers, New-Jersey	140	700	200
Total	1740	6040	2455

each IIT should be producing about 1000 B.Tech.s per year and about 500 M.Techs. per year!.

Let us see the impact of a higher output from IITs. As the universities in US can absorb only a certain number of foreign students (many have said or unsaid quotas), and are already rejecting a vast number of very good applications from India (including many from IITs), the increase in the output of IITs will only marginally increase the number of students going abroad. Similarly, as civil services and management institutes can also absorb only a few more, the number of IIT graduates going into these will also increase only slightly. This implies that most of the added strength will actually end up in the Indian industry, thereby alleviating the shortage of well qualified manpower. If 80% of the added strength reaches the industry, the increase in available manpower trained by IITs will be over 600%! Clearly, this will dramatically increase the impact IITs have on the technology and growth of industry in India. The argument that with a higher S/F ratio the quality of education or research will suffer does not hold, as most of the Universities listed above impart very high quality education and have an excellent track record in R&D.

Another direct consequence of this increased output will be a reduction in the cost of education at IITs. It is well known that the cost of graduating a student from an IIT is very high (of the order of Rs. 3–4 lakhs). As a faculty costs an IIT (with overheads) appx. Rs 2 lakhs per year, and the current production is 1.2 B.Tech.s per year per faculty, just the faculty cost in producing a B.Tech. is very high. If the output per faculty is increased by a factor of 4, the faculty cost will be reduced proportionately. Similarly, since like other government institutions IITs are also heavily overstaffed in terms of non-academic staff, a larger S/F ratio can easily be supported with little or no increase in the staff strength of IITs, leading to a further reduction in cost of graduating a student. This can be viewed in another manner. About 80% of the budget of an IIT is spent in salaries. The money spent on salaries will only increase marginally for increasing the output by a factor of 4. Hence, the cost of IIT education can be reduced to about a third of what it is now by increasing the output per faculty at IITs.

However, it should be pointed out though the faculty and staff need not be increased, or increased marginally, to graduate about 1000 students per IIT per year will definitely require an infusion of capital to increase the capacity of labs, computational facilities, hostel space, civil facilities, etc. Besides the capital requirement for these, the maintenance and day-to-day operation of these will also require additional resources. Managing this level of growth of IITs will also not be straightforward and well thought-out growth plans will have to be evolved. Growth will also require changes in the mode of operation at IITs such that faculty time is not wasted in non-academic or lower-level tasks, and other available manpower at IITs will have to be utilized for such tasks (e.g. teaching assistants will have to be used more effectively for tutorials, labs, etc.).

Advantages to IITs of increased output

Many in IITs will resist this change to make IITs more responsive to the needs of the Nation. However, there are some compelling reasons why it is in the interest of IITs themselves, to increase their output. Indeed, increasing the output substantially may be one way to maintain the relevance and preeminence of IITs.

(a) The 'cushy' days of full government support are clearly over, and IITs will now have to 'earn their existence'. One approach, that is currently being followed, is to increase collaboration with Indian industry and raise funding from them. This is a risky approach which may or may not succeed, as the IIT system and its faculty have little experience in doing the type and volume of industrial work that the Indian industry is likely to support. Increased funding from industry (which will want some returns for it) also has the risk that the academic values of IITs may get compromised.

Another approach to make IITs more relevant today, which is complimentary to increasing industry collaboration, is to do what IITs are best at – education. Imparting high quality education is the biggest strength of an IIT and its faculty. Hence, increasing the education output can be done more easily, and one which will dramatically increase the relevance of IITs without compromising academics. In the current times when the Indian industry is moving towards technology upgradation and indigenous development of technology, highly qualified engineers and researchers are needed now more than ever before and in larger numbers. If IITs can satisfy this demand, and with lower cost per engineer, the importance of IITs to the nation will increase, giving them more 'leverage'. In addition, the government will also find it easier to justify its support of IITs. With the small number being produced currently (and with a minimal impact on industry), full support of IITs can be argued as 'unjustifiable' in the current day of austerity.

(b) It is clear now that scholarships for M.Tech.s are going to go away, to be replaced by a much smaller number of Teaching Assistantships (TA-ships). Clearly the number of TAs will depend on the strength of the UG programme – the larger the number of UGs, the larger will be the number of TA-ships. Hence, to sustain a healthy PG programme, IITs must increase their UG strength. With TA-ships, the faculty time for many activities can be saved, leading to more R&D time for faculty. Furthermore, if IITs produce a larger number of B.Tech.s, some of them are likely to come to IITs for higher studies, thereby increasing the quality of the PG students. Larger PG

programme and reduced teaching effort by faculty will lead to a strengthening of research activities at IITs.

(c) It is also clear that in future a larger portion of the running budget for IITs will come from the tuition from students. A larger number of students will increase this money input. The money input can also be increased by admitting foreign students, who will pay tuition at internationally competitive rates, which will be possible only with larger output from IITs.

(d) Perhaps the most important reason is that increasing the output of IITs may be inevitable to maintain the preeminence of IITs. The IITs made an impact earlier due to the new system of education and its high quality. As the Indian industry could not fully utilize the capability of engineers produced by IITs. their lack of presence in the industry was not a major issue. Now the novelty of IITs is gone, and the issue of 'brain drain' and cost of IIT education are raised even in Parliament. On the other hand, the needs of the industry for highly trained engineers have grown, while the output of IITs relative to the total output of the country has declined. Hence, the importance of IITs for the nation, which is the central reason for its relatively large funding, is being challenged. This trend, unless reversed by IITs, can 'marginalize' IITs resulting in reduced funding and degradation of the quality of IITs. Perhaps the easiest method to increase the relevance of IITs, and definitely the one in which IITs and their faculty will excel, is to enhance its impact on education and manpower development by dramatically increasing its education programme.

Increasing the output of IITs to the level discussed above will definitely require, besides capital infusion, a carefully thought-out plan for change. The issue of managing this change will arise if and when this change is implemented. It should suffice to say that the size argued above is definitely manageable, given appropriate resources – there are many universities and institutions, both in India and abroad, that are much larger in size.

Pankaj Jalote is in the Department of Computer Science and Engineering. Indian Institute of Technology, Kanpur 208 016, India