The AICTE review: an opportunity for engineering education reform

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This article outlines the issues faced by the All India Council for Technical Education (AICTE), the statutory body which governs technical education in India. It points out various lacunae in many areas of technical education such as placements, the use of GATE and JEE scores for selection, accreditation, TEQIP and research in engineering, and the role of the centrally funded institutions. The article also recommends expanding AICTE into a think-tank which may design policy for such an important area.

Keywords: Accreditation, engineering curricula, reforms, technical education and research.

THE All India Council for Technical Education (AICTE) is a statutory body formed by an act of parliament and oversees the conduct of technical education and some of the professional programmes in India. This article is in connection with the AICTE Review Committee formed on 22 October 2014, to review all aspects of its functioning, including the provisions of the AICTE Act of 1987. The Review Committee is composed of several eminent educationists and bureaucrats. The exact terms of reference of the committee are available on the webpage of the Ministry of Human Resource Development (MHRD), Government of India (GoI).

The present author had made a submission to the Committee in January 2015. This article is to make my submission accessible to the general public so as to enable a broader discussion. As we all know, engineering education in India is not doing well at all.

I would like to make the following submissions under various items (i), (iv) and (viii) of the Terms of Reference and also under various sections of the AICTE Act itself, especially Item 10(1) of the Act. As I understand, the Act empowers the AICTE to be the custodian of the important area of technical education in India, and includes (i) admissions of students and measuring performance of institutions, (ii) curriculum design for meeting societal needs, and (iii) guidance on the conduct of research and development.

In my opinion, this review serves as an important opportunity to:

(i) Strengthen AICTE through better knowledge-gathering mechanisms which inform students, administrators and institutions, the industry and the population at large. To design better testing, admission and certification mechanisms which create the right incentives for all-round development of the individual as well as Indian society.

(ii) Enable a more federal approach to the subject, thereby setting up a closer coordination between regional needs and regional institutions in terms of knowledge production. To identify and separate national and strategic needs, and make arrangements for the same.

(iii) Re-orient the conduct of research and pedagogy in science, technology, engineering and mathematics at all levels, especially at elite institutions, to meet the knowledge requirements of society. To bring the interdisciplinarity required in the modern engineer, especially for a developing country such as ours.

My submission is in the form of some background material on specific topics followed by concrete recommendations.

Placements

This is the first job that a graduate obtains, typically through a campus office, and is an important outcome of engineering education. Standard formats for reporting campus placements should be mandatory for aided institutions. This will help the AICTE in assessing colleges, programmes and outcomes. The report should indicate the sector (NIC code) and the ownership structure (such as PSU, Public Ltd, Multi-national, Pvt Ltd), the customer base (e.g. Indian market, global markets) of the company, position offered (design, marketing, management trainee, etc.), salary and academic details such as branch of engineering and academic performance index. Such a uniform format should be recommended from the Indian Institute of Technology (IITs) down to the local engineering colleges. An example analysis of 2013 IIT Bombay (IITB) placements is provided. Some snippets appear in Tables 1 and 2 for 2013 placements for IITB and VNIT, Nagpur.

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Such an analysis will help the institutions, administrators, the Ministry and students considerably. It will also (i) identify successful curricula, pedagogy and practices, and (ii) guide the funding of R&D so that existing linkages are strengthened. For example, from the above data, IITB is well advised to focus on the problem of placing its graduates into engineering for national needs. On the other hand, VNIT will see the opportunity of using its own graduates to develop a sound R&D collaboration with key industries and also analyse and strengthen its curricula.

Accreditation

Accreditation is something that needs due care. As of today, the accreditation documents ask colleges to compare their curricula with 'American professional societies' (see 3.1.3 of Format for Self Assessment Report for Tier I Institutions), thus in effect, requiring accreditation to the ABET institution of USA. Model curricula for some disciplines are available on the AICTE website, but to the best of my knowledge, are only for information and need not be used for accreditation. ABET engineering programmes refer to US professional bodies such as ASCE, ASME and so on, and are designed to suit their scientific and economic infrastructure, and their social needs and chosen trajectory. This may not be suitable for us, given the nature of our industrialization and our societal needs. For example, the ASCE has come up with 'The Civil Engineering Body of Knowledge', a document of 190 pages outlining the historical development of the field, its professional practices, future challenges and a list of what a modern (US) civil engineer should know. In this document, e.g. the word 'sanitation' occurs once (in the chapter on globalization) and the word 'sewage' does not occur at all. Thus, given that we have a great need for sanitation and sewage services and active programmes (e.g. Swachh Bharat) in the sector, accreditation to the ASCE programme would be unsuitable.

Indeed, AICTE must come up with such 'Body of Knowledge' documents in each branch of engineering and also the applied social sciences. These documents should realize the role of the small and medium sectors, the pending development agenda of sadak, bijlee, paani as well as strategic needs such as in telecommunications or railways, as important objectives for curriculum design.

In fact, the Washington Accord recommends (see http://www.ieagreements.org/IEA-Grad-Attr-Prof-Competencies.pdf) that each signatory identify key stakeholders and create an outcome-driven framework for defining engineering, stressing the role of the engineer as a societal change agent. See, for example, attribute WA3 of the Washington Accord: 'Design solutions for complex engineering problems and design systems, components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations.'. Thus, the Washington Accord actually recommends a curriculum and processes suited to societal needs.

One must also mention about our Prime Minister's speech at the President's meeting with the IIT directors, on 22 August 2014, where he said that 'science is universal, but technology is local'. This implies that there should be space for courses which have a regional flavour, e.g. in Maharashtra, irrigation may be more important, while in Himachal Pradesh, hill roads and bridges may form a full semester course. Unfortunately, neither the AICTE model curricula, nor the GATE curricula or the curricula offered at the IITs/NITs allow such regional, strategic or developmental adaptations.

Table 1. Placements (2013) of undergraduate and postgraduate students of major departments in IIT Bombay

Sector	Engineering	Finance	Consulting	IT
Super-GG	25 (27.7)	10 (35.0)	7 (54.0)	42 (51.3)
GG	116 (7.9)	82 (11.7)	110 (9.6)	102 (10.0)
IG	54 (6.5)	19 (7.2)	11(5.8)	28 (7.2)
GI	24 (9.3)	10 (14.2)	10 (5.2)	5 (9.3)
II	64 (6.5)	13 (9.5)	8 (5.8)	22 (7.9)

GG, Global company serving a global market (e.g. Bank of America or General Electric); II, Indian company serving Indian markets (e.g. Ambuja Cement or Tata Motors); IG and GI are similarly explained, i.e. Indian company serving global markets and global company serving Indian market respectively (e.g., Infosys and Hindustan Unilever). Super-GG are placements to positions situated abroad. The figures, e.g. 116 (7.9), indicates the number placed and the average annual salary in lakhs of rupees.

Table 2. Placements (2013) of all students at VNIT Nagpur

Sector	Engineering	Finance	Consulting	IT
GG	16 (7.2)	11 (10.1)	36 (5.0)	30 (5.0)
IG	6 (4.8)	0	0	37 (4.0)
GI	43 (4.7)	0	0	0
II	207 (4.5)	2 (4.8)	0	0

GATE

In the absence of any guidance from the AICTE or National Bureau of Accredition (NBA), the GATE syllabus is the *de facto* definition of an engineer in India. This is evident from the role that GATE now plays in opening new opportunities for the fresh graduate, viz. from entrance into elite M Tech programmes to job recruitments, especially into PSUs. Moreover, even before this, a large fraction of engineering graduates have been writing GATE. For example, in 2010, the number of students writing GATE was about 4 lakhs which had swelled to 9.8 lakhs by 2013. Thus, GATE is already an important certification examination for engineers in India and needs to be incorporated into AICTE processes.

However, the conduct and reporting of this examination is decided by the older IITs and Indian Institute of Science (IISc), Bengaluru. This curriculum is largely based on the faculty expertise of the organizing institutions, existing undergraduate (UG) curricula, the type of graduate students that they require for their research purposes, and the amount of effort that they wish to put into it. For example, consider the topic of 'concurrency' in Computer Science and Engineering (CSE), which appears in two areas, viz. databases, and operating systems, and was a traditional research area of faculty members in these institutions. It is unclear if concurrency is industrially important, can be taught by a wide body of faculty members across our engineering colleges, and that its ramifications in both databases and in operating systems are important attributes of a typical CSE graduate of the country.

Moreover, as Tables 1 and 2 suggest, the IITs and IISc have been sending a minority of their graduates into engineering jobs and fewer still into engineering for domestic needs. The typical syllabus in GATE is what is taught at the IITs/IISc and which is largely theoretical, and needs about 12–14 core courses. For example, most graduates from IITB would not have visited a factory or a water supply system, let alone a firm in the small and medium sector, the mainstay of domestic engineering. However, most colleges do not have the requisite faculty strength and expertise to teach the above 12–14 theoretical courses (though they may be placing more students into domestic engineering), and students must take recourse to coaching classes.

Finally, the multiple-choice format for GATE is a reflection of the amount of time the IITs and IISc faculty members are willing to spend on screening students for their graduate student admissions. It cannot be used to measure the fairly subtle skill of engineering, which is a combination of both practical skills and theoretical competence. Moreover, the time-bound objective-type format devalues a range of other important engineering skills such as system design, field observations and field work, and also inter-disciplinary skills. It is also unsuitable for testing research abilities and many IITs now rely on an elaborate interview process as well. I must add that GRE discontinued the Engineering Subject Test in 2001 and the Computer Science Subject Test in 2013.

The insistence on such a theoretical and largely unimplementable definition of the engineer, and to test it without field context, in a computerized framework, perpetuates a dichotomy between the elite institutions and regional institutions which has proved insurmountable for over 50 years now. I think a structuring of GATE into a set of 5–6 MUSTS and 5–6 optional/regional courses would ease the pressure on engineering colleges and focus their attention on (i) getting a few basic courses right and (ii) supplement their programmes with courses which meet regional engineering requirements. Even these 5 MUSTS should be defined after a broad consultation between the broader academia and industry, including the needs of informal sector and core development sectors. Using GATE and joint student projects, elite and regional institutions must enter into a virtuous cycle of improvement, which must begin at the current level of competence of regional institutions. Independently, even if a time-bound objective system must be used, more thought should go into the design of the question paper and the coverage of topics. A public report on the outcome of GATE, aggregate and question-wise statistics should be maintained and supporting research must be done so that it evolves into a robust certification examination. See, for example, the detailed academic analysis of the GRE and SAT suite of examinations, and the important role this academic analysis has played in the US education system.

Interdisciplinarity

The engineer is now recognized as a social and cultural actor and a change-agent. Moreover, this is enshrined in the Washington Accord thinking as well. This is especially true for a developing country such as India, where engineering should be about design for a societally posed problem, and solved in the socio-economic context in which the problem is posed. This needs interdisciplinary skills of societal assessment, problem formalization and description, decomposition of a problem into disciplinary sub-components, design and synthesis, and finally deployment and outcome measurements. It requires a change in the way social sciences and physical sciences are taught. In social sciences, students must understand the practical structure of society, the role of the state, market and civil society. It also requires a familiarity with standard datasets such as Census, District Economic Surveys, and with flagship Government programmes and key private sector players, e.g. in the water sector.

In physical sciences, core scientific areas which are developmentally important such as groundwater and cooking energy, must be incorporated into the science curricula. Moreover, the cultural moorings of science, for example, the skills of description and argumentation, play an important role in the design of scientific experiments and the development of rigour. These should be recognized as part of the training in science for it to yield significant insights and progress which benefit society. The new training should also stress that most true science is far more applied and empirical and with a multitude of 'right' answers. Consider, for example, the question of determining the 'best' chulha in the village, which throws up many points which require methodological and scientific innovation.

This, of course, requires a long-term programme for institutions to undertake and the development of innovative pedagogical methods, such as project-based field work and a topical case-study approach. This, in turn will require great leadership from the elite engineering institutions, i.e. IITs, NITs, the elite science institutions such as IISERs and IISc, and the elite social science institutions. In fact, the recently launched Unnat Bharat Abhiyan of MHRD is an important framework which extends the definition of science and engineering in an important way, i.e. into the concrete development agenda and into recognizing the role of the elite institutions as leaders in creating a new curricula and methods for a developing country. Perhaps, the AICTE should come up with a series of Body of Knowledge documents and a National Curriculum Framework under which this activity will be carried out.

TEQIP and other World Bank projects

An important programme in the recent past which impacted technical education is the World Bank funded TEQIP I and II programmes of GoI for selected institutions in engineering. Most of these were Tier I and II institutes and were largely the NITs or state colleges. Besides 'academic excellence' and better governance, one of the core objectives of the programme was 'providing service to community and economy through linkages and active interaction with industry, government, and other stakeholders, formal and informal sectors of the economy, adult learners, and all who seek or need technological assistance'. Thus, at least in principle, it expected colleges to develop linkages with the region and with regional agencies.

An independent review of TEQIP-I was not very positive on many of the stated objectives. About 59% of the institutions had less than satisfactory performance on the 'key performance indicators' (KPI). One of the KPIs measuring excellence was the number papers published in national and international journals which has led to an increased focus of faculty members on 'global' research to the detriment of their own capacity to innovate for regional problems. From my visits to colleges in Maharashtra, and in my opinion, this has damaged some of the regional relevance that institutions used to have. Faculty members who would have been good role models for doing relevant work have fallen behind and somewhat questionable research work has come to the forefront and is used by administrations to allocate resources. A sampler of this is Table 3, in which we collate the number of papers indexed by Scopus, in which at least one of the authors is from India and the phrase is part of the title.

It is unclear why 'neural networks' has become such a central area for research amongst Indian scientists. Table 4 shows the number of papers with the same attributes, but in areas which are developmentally important. Thus, KPI of the 'number' of publications may be hiding an essential misallocation of effort and funds into research in areas which are not relevant. Another KPI is the average salary of graduating students, which as we have already argued, can also be misleading since it does not quite capture if these students are actually placed in engineering or allied fields. TEQIP III, which is under design, must ensure that gaps of TEQIP I and II and addressed.

Moreover, a key recommendation of the independent assessment was for institutions to engage further with their regions and work with regional agencies for their research. The World Bank itself is engaged in many sectors in India, e.g. water and electricity, and most of the work needs regional partners. Consider, for example, the World Bank Neeranchal Watershed Project of 2014, which aims to improve watershed outcomes across various states and strengthen the Integrated Watershed Management Programme of GoI. Neeranchal retains the National Institute of Hydrology (NIH) as a key knowledge provider at the Centre. However, in the states, where most of the work will be done, it does not link up with regional institutions, e.g. TEQIP colleges, but looks at NGOs as possible partners. This misses an important opportunity for capacity building of formal knowledge institutions and a partnership between these and the state agencies.

The World Bank is an important (and expensive) knowledge agency and brings many skills and practices. The AICTE should ensure that such opportunities of collaboration are not lost and that a close research and practice-based relationship develops between apex institutions, multi-lateral agencies, state and regional institutions, and regional agencies. Both these points may be addressed in TEQIP III.

JEE Mains and JEE advanced

Just like GATE, the JEE examination in effect, serves to define the outcome of school education in science and

Table 3. Number of papers with phrase in the title and with at least one author from India (Scopus)

Topic (phrase)	All years preceding 2003	2003–09 (TEQIP I)	2010 onwards (TEQIP II)
Neural network	692	1818	2467
Fuzzy logic	110	327	759
Wavelets	96	905	1846
Genetic algortihms	262	989	1373

Table 4. Number of papers with phrase in the title and with at least one author from India (Scopus)

Topic (phrase)	All years preceding 2003	2003–09 (TEQIP I)	2010 onwards (TEQIP II)
Water supply	84	74	87
Sanitation	30	51	63
Groundwater models	11	29	70
Public transport	5	15	25
Power grid	12	56	288

mathematics, much to the detriment of the state Board examinations. The precursor of this system was the AIEEE, which was used to admit students into the NITs and the IITs, and a few other institutions. The JEE was used for admitting students into the IITs. However, this system was merged in 2013 and now JEE (Mains) is the examination which is used to admit into the NITs and is used to qualify students who are permitted to write the JEE (Advanced), for the IITs. Since 2014, some states (e.g. Maharashtra) have discarded their own admission examinations (CETs) and are now using the JEE (Mains) to admit students. Thus, the JEE is now increasingly important to a larger body of students and is the *de facto* measurement of preparation in science and mathematics. More than 10 lakh school students gave this examination in 2014, which is a substantial fraction of all high-school students who did Sciences in class 12. Given the numbers, the examination is administered in a nation-wide time-bound multiple-choice format on the CBSE high-school curriculum. Moreover, it is a ranking examination as opposed to a qualifying examination, and the student's rank in the examination is usually the sole criterion in determining her admission. The preferred outcome is of course, admission into the IITs or the NITs, which make up roughly 20,000 seats, i.e. about 2% of the total number of students writing the examination.

However, there are several serious problems.

Disruption of state curricula

A look at the statistics of JEE (Advanced) 2014 shows that 55% of those who qualified came from CBSE. Other top scores were Andhra Pradesh (17.5%) and Maharashtra (6.7%). All other state boards contributed to less than 2% of the qualified candidates. As a result of this and pressure from middle-class parents, many state boards (e.g. Maharashtra and Andhra Pradesh) feel compelled to match their curricula with CBSE, the curricula closest to that for the JEEs. This results in a global definition of science and its pedagogy for all students, rural or urban. Much material which is of local or regional relevance, e.g. the analysis of droughts, or a pedagogy of field-based science may either be absent or is de-emphasized since it does not match the JEE format or content. This is over-centralization. Even the famous Gao Kao examination of China is conducted on Province-specific curricula.

Moreover, the students in the CBSE Board have a different socio-economic background and face a different world compared to students from the state Boards. Thus, it is not clear whether the CBSE curricula for science or mathematics is suited for state governments faced with a largely vernacular, economically stressed and possibly rural student body. The correct pedagogy and content for science for such (if not all) students should be that which connects with the immediate material world around them and helps them probe it along with the socio-economic context, e.g. natural resources, basic services such as water and energy. Only then will they be prepared to make correct choices for themselves and the society. Compare this with the stated rationale of the physics NCERT curriculum for the classes XI and XII, quoted below:

The higher secondary stage is crucial and challenging stage of school education as it is a transition from general science to discipline-based curriculum. Physics is being offered as an elective subject at the higher secondary stage of school education. At this stage, the students take up Physics, as a discipline, with a purpose of pursuing their future careers in basic sciences or professional courses like medicine, engineering, technology and studying courses in applied areas of science and technology at tertiary level. There is a need to provide the learners with sufficient conceptual background of Physics which would eventually make them competent to meet the challenges of academic and professional courses after the higher secondary stage. The present effort of reforming and updating the Physics curriculum is an exercise based on the feedback received from the school system about existing syllabus and curricular material, large expansion of Physics knowledge, and also the educational and curricular concerns and issues provided in the National Curriculum Framework-2005. The recommendations of National Curriculum Framework-2005 have been followed, keeping the disciplinary approach with rigour and depth, appropriate to the comprehension level of learners. Due care has been taken that the syllabus is not heavy and at the same time, it is comparable to the international standards. Also, it is essential to develop linkages with other disciplines for better learning of Physics concepts and establishing relationship with daily-life situations and life-skills.

Thus, we see that 'daily-life situations and life skills' are the last six words in a rationale of 230 words. The rationale for the NCERT mathematics curriculum is similarly 'transcendental'. Thus, state Boards are ill-advised to adopt the CBSE curriculum for their own students and the JEE examinations are ill-advised to adopt such a curricula and format for their examinations.

Unsuitable format for testing science and mathematics

As mentioned earlier, the JEE is a nation-wide exam of science and mathematics conducted on a single curriculum, viz. the CBSE, and in the time-bound multiple-choice format. Moreover, the number of students appearing is about 10 lakhs, most of whom are nominally competing for about 20,000 seats in the IITs and NITs, i.e. with a success rate of roughly 2%. The IIT brand then establishes itself by student festivals, celebrity academicians as visitors (such as in the newly proposed GIAN programme), and primarily, the stellar ‘packages’ (i.e. salaries) of a few IIT graduates. This makes it the single most competitive examination in India and one which captures the imagination of the media and most middle-class parents. The main reasons for the chosen format for the JEE examination are (i) given the high stakes, a subjective examination will be difficult to correct ‘fairly’ and will be liable to legal contestations, and (ii) unavailability of faculty time in designing a question paper and correcting 10 lakh answer papers.

However, if one describes (following Krishna Kumar[1]) the culture of science as that of touching and manipulating the material world, and of personal observation and contemplation, then the JEE actually promotes quite the opposite. It measures facility and familiarity with arcane mathematical identities, highly stylized textbook models motivated by mathematical laws of physics, and huge amounts of rote work and practice. Since only the top 2% is admitted to the IITs or NITs, the exam-taker must have excellent skills of question selection, elimination and informed guess-work, making it one of the most highly coached examinations in India. This has its own socio-economic problems which are visible from the rural–urban divide and the gender distribution of the students who pass JEEs. Table 5 provides distribution by gender of students who appeared and were successful.

Note that JEE 2012 was conducted by the IITs. The percentage of girls who wrote the examination was already low at 33.2. The number who succeeded was down to 11.9%. For 2013, the data on JEE (Mains) are not available on-line. Since most of those who qualify in JEE (Mains) would register for JEE (Advanced), we can surmise that the fraction of girls who passed JEE (Mains) 2013 must be close to 18.2%. This number is again rather low. After JEE (Advanced), this number drops down to 11.4%, close to the fraction of 2012. Note that (i) more girls opt to NOT give the JEE, and (ii) their pass percentages are also low. The same pattern is seen in the Kishore Vaigyanik Protsahan Yojan (KVPY), a competitive examination which locates the top 1–2% of students who wish to pursue pure science. Moreover, this also flies in the face of evidence that close to 30% of all engineering students are now girls.

We compare this to the CBSE data (Table 6).

We see that in the CBSE examination, a subjective one allowing for a wider variety of questions, and of a longer duration, on the same curricula as the JEE, and one which is graded by human examiners, girls did much better than boys. Thus, one must conclude that it is the nature of the examination and other factors surrounding it, such as access to coaching, that prevent girls from being admitted into the IITs.

Next, let us also look at the rural–urban divide (Table 7). Note that JEE 2011 and 2012 were before the amalgamation of JEE and AIEEE, while JEE (Advanced) 2014 was sourcing applicants from JEE (Mains).

We see an increasing polarization where students from rural or small-town backgrounds are increasingly less likely to register and also to succeed in the JEEs. About 76% of students are now coming from cities as opposed to villages and towns.

Moreover, if we look at the ‘mode of preparation’ for this examination, as reported in the JEE (Advanced) 2014 report, we see that about 37% of those who qualified in JEE (Mains) reported that they had used methods other than ‘self study’ (i.e. had availed of coaching). This fraction rose to 43% in those who qualified in JEE (Advanced). Another revealing study is the income of parents of students who qualify in JEE (Mains) 2014 versus those who qualify in JEE (Advanced) 2014, where we see that students from the income annual income class of Rs 8 lakhs and above are about 2.7 times more likely to succeed than those from an annual income class of less than Rs 1 lakh. Note that the data on rural/urban background, preparation and income of parents are as reported by students and that itself is likely to be strategic. Reporting lower incomes and self-study as the method of preparation does increase the chances of receiving scholarships.

A final piece of data is culled from the NSSO, 68th round household survey of 2011–2012. Table 8 shows the analysis of annual household expenditure on education for a sample of states and the rural and urban sectors. The first two rows show the mean annual per capita consumption and the number of total samples in the 68th round. These rows should be used as reference points for the remaining rows. Next, we report the number of samples, the mean and the Gini coefficient for households which had either one girl or one boy who was studying. More detailed analysis is available upon request. This analysis clearly shows a sharp variation across states, across gender and across rural versus urban backgrounds. Other than Tamil Nadu, all states show a much higher spending on boys than on girls. The higher spending on girls in Tamil Nadu may well explain the higher number of girls who pass JEE from the South Zone (administered by IIT Madras); again see the JEE (Advanced) 2014 report.

As can be seen, the Gini coefficients are all above 0.5 and are exceptionally high, showing a great disparity on spending on education. This probably arises from information asymmetry across households and also access to coaching classes from the place of residence. The disparity in the number of samples also indicates that substantially fewer households with girls are spending on their education.

On the whole, the data show that it is unlikely that the JEE is measuring student preparation in science and mathematics and her aptitude for engineering. The format of the examination is likely to encourage coaching and discourage independent thinking or a science which is inspired by our surroundings and of solving problems therein. We should also point out that the excessive selectivity of the JEE process is probably leading to a misallocation of IIT

Table 5. Selected JEE statistics on gender

	JEE 2012			JEE (Advanced) 2013		
	Appeared	Qualified	Pass percentage	Appeared	Qualified	Pass percentage
Boys	337,916	21,226	6.28	103,660	18,468	17.8
Girls	168,568	2886	1.71	23,089	2366	10.2
Percentage of girls	33.2	11.9	–	18.2	11.4	–

Table 6. CBSE 2013 statistics

Gender	Appeared	Secured 90% marks	Percentage of total	Secured 95% marks	Percentage of total
Boys	512,210	22,596	4.4	2855	0.56
Girls	376,410	22,053	5.8	3237	0.86
Percentage of girls	42.4	49.3	–	53.1	–

Table 7. Rural–urban statistics for JEE

	JEE 2011		JEE 2012		JEE (Advanced) 2014	
Cohort	Registered (%)	Qualified (%)	Registered (%)	Qualified (%)	Registered (%)	Qualified (%)
Village	18	10	19	11	13	10
Town	29	25	30	26	19	14
City	53	65	51	63	68	76

Table 8. NSSO (2011–12, 68th round) statistics regarding annual household expenditure on education

	Unit	Andhra Pradesh urban	Andhra Pradesh rural	Rajasthan urban	Rajasthan rural	Odisha urban	Odisha rural	Tamil Nadu urban	Tamil Nadu rural
Per capita expenditure	Mean (Rs)	47,124	35,664	30,948	18,588	35,676	12,636	40,788	39,936
Number of samples	Number	1754	2685	1598	2442	1003	1941	1693	2662
Households with one studying male	Mean (Rs)	9919	5706	19,096	4362	5765	1787	11,046	8493
	Number of samples	365	373	235	263	143	291	373	293
	Gini	0.61	0.58	0.56	0.64	0.65	0.70	0.64	0.67
Households with one studying female	Mean (Rs)	9233	3752	9369	3431	4278	2292	12,653	6949
	Number of samples	281	245	98	126	94	191	321	259
	Gini	0.61	0.55	0.60	0.56	0.82	0.76	0.65	0.69

The Gini coefficient is a scale-invariant measure of inequality in a set of positive numbers, e.g. earnings of individuals, or as in this case, expenditures and takes values between 0 and 1. A Gini coefficient 0 indicates total equality, while that of 1 indicates total inequality, i.e. zero expenditures by all but one individual. For a population in which one-fourth of the people spend three-fourth of the money, the Gini coefficient is 0.5.

graduates to the global service sector as opposed to engineering for Indian needs.

The role of the IITs, NITs and IISERs

The role of and the expectations from these premier institutions in India's technical education infrastructure is not clear. There are overlapping Acts which lead to several questions, e.g. are the IITs covered by the Washington Accord? As of now, these institutions wield substantial influence on technical education, various policy decisions and programmes (as witnessed by the Preamble of the TEQIP programme) and even the conduct of the AICTE (as witnessed, e.g. by the composition of the Review Committee). It is only reasonable that the *locus standi* of these institutions be made clear.

More important is the connection of their research with teaching and the national agenda. Since much of the research funding from GoI goes to these institutions, the AICTE should suggest clear and concrete expectations on the outcomes of this research for the benefit of its members. This is all the more important for new investments in these elite institutions, e.g. in the form of international faculty exchange (e.g. the newly proposed GIAN initiative), or in specific research programmes (such as in Nanotechnology). One possibility is to require at least some of this research should lead to new courses (and matching faculty), in key sectors such as groundwater or cooking energy. Moreover, elite institutions may forge new liaisons with state and district administrations, or with companies in strategically important areas such as telecommunications or railways. These liaisons and ways-of-working may set a precedent for academia–industry–state interactions and translate to new job definitions. However, for much of this to happen, there needs to be closer collaborations between elite and regional institutions on both academic programmes and research.

I will close this submission with the following reiteration:

(1) Technical education in India is not functioning at its best and faces many challenges. I must add that many development outcomes such as drinking water and cooking energy are actually in the realm of engineering. These are in poor shape and need better engineering, more research and a partnership between elite and regional institutions, and public and private agencies.

(2) The domination of state-funded elite institutions comes with a responsibility. With a selectivity of 2%, it is important that 'losers' benefit from participation in the process, for otherwise the elite institutions will eventually lose both legitimacy and support. This should be in the form of an elite agenda for (i) a pedagogy of science and engineering which is more inclusive, and (ii) better development outcomes through research, new job definitions and better jobs. See Sohoni[2] for a broader argument and a road-map.

Reviews of key institutions such as the AICTE are rare and present an important opportunity for both short-term measures and long-term course corrections. The ACITE must pave the way for the broader reform which is required to move itself and its member institutions onto a new path of technical education and research. This should match student aspirations and national and regional demands with the capacities of institutions, their research and their pedagogy. The AICTE should also consider expanding itself into a think-tank which will help it move to a new regime of rigorous measurement of outcomes and a broader discussion on the meaning of scientific and technical education for a diverse and developing country such as ours.

Notes

Many authors have commented on different aspects of the structure of engineering education in India, a common topic being postgraduate (PG) education in engineering, research and its metrics, and the JEE and its consequences. Subbarao[3] looks at the IITs, their research and the status of PG training in India. Desiraju[4] reviews the IITs and the CSIR as institutions and comments on elite institutions as the 'icing on the cake' but where the cake is missing. On the JEE, there have been many articles analysing various policy switches that have taken place in its implementation[5,6]. The social analyses of Prathap[7] and Sohoni[8] are perhaps similar to the present article.

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