

Science Education and Research in India

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Many aspects of the Indian scientific development are extremely unsatisfactory, lacking in both quality and quantity. Although the outreach of teaching and research programmes has increased considerably, populist political themes are favoured and special institutions have been created where research is undertaken independent of the university system. This article reviews the present scene in science education, and identifies the major problems and the challenges confronting the institutions involved in education and research. It suggests that the government should restrict itself to broad policy issues rather than be involved in day-to-day affairs and the university should be re-established as the primary agency for education and research.

The era of procrastination, of half-measures, of soothing and baffling expedients, of delays, is coming to a close. In its place, we are entering a period of consequences.

—W S Churchill, during the locust years of the rise of Nazi Germany

Scientific progress is the hallmark of a dynamic society. The scientific temper is probably the best answer to ignorance, superstition and hypocrisy. It encourages a logical, quantitative and systematic approach to life, rapidly empowering and enriching those who embrace it in their lives. Our newly independent country took many moves to increase and improve scientific activity. The feeling today however, is that many aspects of our scientific development have been unsatisfactory. When compared with what other countries, notably China, have achieved within a similar time period, the Indian contribution is singularly lacking in both quality and quantity. This article attempts to provide a survey of the present scene in science education and research and to suggest possible solutions. It is the perspective of a person who has been involved with science in India for almost 30 years as a teacher and researcher in the University of Hyderabad, and who has also had extensive interactions with the international scientific community at many levels.

At the outset, it is important to specify the kind of science one is speaking about. There is science as a scholarly activity, industrially-oriented science, science in society, science for the student, and science for strategic purposes. The aims and goals of these varied kinds of science are indeed distinct, as are the methods employed to achieve success in any of them. Developing rocket technology is not the same as publishing high impact scientific papers, which in turn is different from discovering a new drug or solving the

drinking water problem in our villages and towns. However, there is a common theme that links all these activities, and that is the importance of having a critically large and competent scientific workforce. In turn this means that one needs to impart a modern and sensible science education across a wide cross-section of youth in order that they might reasonably develop themselves as scientists or scientifically inclined people of the next generation. Any attempt to divorce science education from the rest of science is therefore doomed to failure, as we have now realised to our very great cost.

1 General Background

In the past, scientific research in India was a low key affair but it was competently done, given its flimsy infrastructural support and absence of equipment. A dedicated teacher and a few motivated students could create a happy academic environment. Quality was the goal, and though elusive there was never any doubt about identifying it when it surfaced. Today, however, vast numbers of students aspire for educational opportunities at higher levels. In the name of democratisation, we have been told by our political masters to increase the outreach of our teaching and research programmes. Can we cope with this projected increase? Our system which evolved in gentler times is incapable of handling populist political themes that promise to deliver education at all levels to the masses.

Actually, it is impossible and also unnecessary to make every student a high profile researcher. Research is elitist, exclusive, discriminatory, and at the highest levels of outstanding quality. Excellence in research is like high altitude climbing or marathon running. It is not meant for all. At more modest levels, a few more can participate, but that is the bottom line. Still, there is nothing wrong in moving from the slow paced quality based system which we had 25 years ago, to a more accelerated quantity based system, provided the ultimate goal is the identification and encouragement of true quality. Quantity does not mean loss of quality. Quantity is also no substitute for quality.

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How does quality research fit into a quantity-based system where everyone wants to study?

For this, education must evolve in two stages: in the first stage a very large number of students must be given a sound undergraduate training in science, including laboratory work. In the second stage, a smaller number of truly gifted individuals must be identified and given a world class education. Simultaneously, those who terminate their education at the undergraduate level should be provided with decent employment opportunities. Two elements are required for this: (i) the numbers of students handled at the lower levels must be really large; and (ii) the thoroughness with which the system is able to identify and elevate quality must be highly efficient. This is the so-called "needle in the haystack" problem. If large numbers are screened effectively, one would get the golden mean of quantity at the lower levels and quality at the higher levels. Many competent scientists would be able to contribute effectively in certain activities, and a few really outstanding ones in others.

Sadly, the present situation is characterised by neither quantity nor quality. No one is really interested in a bsc degree because science as a career is not perceived as a serious option by students and their parents. Only the debris remains in the bsc programme. Substandard undergraduates become substandard PhD students. No scientific institution in India, however glamorously it may be touted by the news media, has avoided this problem of deteriorating student quality. There were days when a small number of bright students somehow drifted into the so-called prestigious places, and there was this fig leaf of respectability. Today, the rot has spread all the way to the top. Students do not want to enter a scientific career because they do not see attractive economic prospects at the end of their studies. One may argue with this attitude, but it is unavoidable in our money-driven society today.

2 Identifying the Problems

We identify here three major problems that need to be addressed to promote excellence in research in science.

(i) Research and Teaching: In every country that has a significant scientific presence, fundamental research takes place in universities that handle undergraduate teaching. For historical reasons, however, Indian universities were organised as examination-oriented bodies with affiliated colleges; the British authorities were careful to ensure that significant research did not take place in them. The newly formed government of independent India was well aware of the problems within our universities, their inflexible bureaucracies and entrenched interests, and rather than try to reform them straightaway (which would have been the only lasting solution), they attempted to sidestep the issue by creating institutes where research could be undertaken independent of the university system. This was the beginning of organisations such as the Council of Scientific and Industrial Research (CSIR), Indian Council of Medical Research (ICMR) and Indian Council of Agricultural Research (ICAR). In my view, this was the single biggest blunder that was committed in the Indian scientific arena.

Today we continue to pamper these unproductive behemoths which have usurped the functions of the universities, and have been unable to generate any kind of quality in their own research, apart from failing in their basic mandate of acting as a liaison between the academic and industrial/societal worlds. Recently, we have also created smaller and more exclusive institutes, the so-called "islands of excellence" from where it is fondly hoped that future Nobel prizes will emanate, but this is just adding insult to injury. The National Knowledge Commission (NKC) (2006) has strenuously spoken out against the creation of these elite institutes which ill befit a country of one billion with the weird combination of an 8 per cent annual growth rate and one of the largest proportions of illiterates in the world. Creating these institutes is like curing an inoperable cancer with band-aids. There are no two ways about it. The best researcher may not make the best teacher, and vice versa, but research and teaching always go together. They are two sides of the same coin. Teaching without research is like a pond of stagnant water.

It becomes stale and contaminated. Research without teaching is like a mirage. We imagine that there is water in the pond.

(ii) Science and Engineering: Somewhere along the line, we Indians became enamoured with engineering and other professional courses. Possibly this had to do with the fact that an engineering degree was associated with immediate employment, which is always an important factor in a poor country. Perhaps it had to do with the Indian Institutes of Technology (IITs) and their so-called "world class" image, more probably the ease with which an IIT graduate was able to emigrate to a foreign country. A very large number of engineering colleges were started to accommodate the terrifying demand for this course but, for the large part, these colleges were of substandard quality and their graduates were ill-equipped to handle a professional career in engineering. Simultaneously, employers started insisting on an engineering qualification as a basic prerequisite for any kind of moderately paying job, and this truly sounded the death knell of the bsc colleges.

Our society's infatuation with the engineering course is the second big misfortune that has befallen our scientific enterprise. I have come across a large number of youngsters who had absolutely no aptitude for engineering: some of them would have made fine economists, journalists, authors or even artists. Yet, because of tyrannical parental and societal pressure they undertook studies in engineering and this was the beginning of a long, costly and in many cases disastrous journey into the darkness. This is a crisis of confidence. The government must convince the general public that a sound BA or BSc course in which the student is taught with honesty and dedication will necessarily result in immediate and gainful employment. Not everyone should want to become a space scientist or, more ludicrously, a data puncher in the United States. Most should be happy to work in India as, say, a bench chemist in a factory, a teacher in a small college or a cameraman in a TV station. A sound undergraduate degree is all one needs for this. It is both necessary and

sufficient for this level of work, and no dignity is lost.

(iii) Curiosity and Courage: C V Raman said that there is nothing intrinsically inferior with the quality of the Indian mind when compared to that of a Teuton or an Anglo-Saxon. Rather, he added that what inhibits us is the lack of a certain courage that would allow us to explore unusual avenues. To this I will add that the average Indian lacks a constructive curiosity and interest in goings-on around him or her. The Indian is far too self-absorbed and believes that there is no need to know about many things because it does not help him or her to address an immediate, personal concern. Courage and curiosity are, however, the two essential attributes of a good scientist and their singular lack in the Indian psyche have contributed in no small measure to the deterioration of our science. This is the third of the big problems we face. It is remarked often that an Indian makes a good student or postdoctoral fellow but a poor scientist when (s)he attempts to do independent research. The Indian is too scared to question authority of any form. He would rather swim along with the current. He does not dare to differ. All this runs counter to the scientific disposition, which proceeds systematically along the route of questioning, formulation, experimentation and verification. How do you formulate a hypothesis if you are scared to do so?

I believe that neither curiosity nor courage is a genetic trait – these qualities are inculcated in the early years, by broad-minded parents and compassionate teachers. Our society places too much premium on conforming. All rewards will be yours if you toe the line, they say. Do your own thing and you will be punished. Do not take up humanities or social sciences, we are told. Qualify for the IIT or perish. Join an Indian Institute of Management (IIM) because otherwise you have failed in life. Do a PhD and then go to the US for a postdoctoral fellowship. Earn dollars and be happy.

What chance is there for any genuine scholarship and enquiry; in fact what chance is there for anything positive in such a straitjacketed environment? We are creating zombies and not productive

members of society. We need a cleansing of the Augean stables within our minds, but there are no short cuts. Charity begins at home, in this case in elementary school. Unless each little child who enters school is respected as a distinct human being with his or her own preferences, choices and rights, there is not much hope of enabling a courageous new generation.

3 Our Institutions

This section deals with the challenges confronting our universities.

Indian Institutes of Technology: It is indeed ironical that the premier institutes that were started with so much sincerity of purpose have deviated so far from their original aims. Nehru had a definite objective for the IITs. He envisaged them as a cornerstone in our industrial and technological edifice. What do we have in practice? For the first 20 years (1960-1980), the best of the IIT output emigrated, mostly to the US, literally draining the intellectual capital of the fledgling country. The next 20 years saw a hiatus during which the quality of the teaching programme declined and research in engineering dwindled to nothingness. Curiously, it was during this time (1980-2000) that admission to the IITs became a frenzied business and when the notorious cram schools of Andhra Pradesh, Kota (Rajasthan) and elsewhere became vast empires, pretending academic eminence. Candidates without aptitude were thus able to qualify for admission and a dull sort of mediocrity set in. The IIT graduates are not rushing off to the US today, not because they have suddenly become patriotic but rather because they are not being offered student assistantships and lucrative jobs in the US anymore.

Perhaps these IIT graduates are not as good as they used to be. Things are aided and abetted by companies that refuse to hire anyone except IIT graduates, howsoever mediocre they may be. I feel that the IITs are highly overrated today and that their so-called “world class” status is largely a creation of the Indian media. In part, their problems arise from the fact that their admissions are made exclusively on the basis of an entrance examination (IIT-Joint Entrance Examination), and

education there is subsidised heavily for all admitted students.

In contrast, the really top universities of the world (Harvard, Cambridge, Berkeley) have a dual system of admissions. The window of scholastic ability to secure admission into these institutions is a little wider than in the IITs. Really outstanding students are awarded full scholarships while others, who are very good but not the very best pay rather heavy fees. This provides a healthy balance, and prevents an undue domination by products of cram schools, who can crack examinations but are good for little else.

The contribution of the IITs to the research activity of India has been negligible, at least in the engineering disciplines. Indirectly, they have had a very negative effect on science because the best students of the country joined the IITs as engineering students rather than opt for a scientific career (whether or not they had any real aptitude for engineering). Unfortunately the IITs cannot be wound up, but they need to be regarded with a great deal of realism and should be made accountable for the amount of largesse they receive.

Council of Scientific and Industrial Research: Once again, we have an organisation that was set up with the most laudable of objectives, namely, to act as a bridge between the academic and industrial worlds. However, the CSIR laboratories began to encroach upon activities which are traditionally in the purview of the universities – guiding students for a PhD degree, publishing scholarly papers, conducting qualifying examinations for PhD admissions, and giving out prizes and awards. However, they are not degree-granting institutions and so they needed the “assistance” of nearby universities. So, and as examples, Delhi University, Poona University and Osmania University gradually became post offices that handled the official correspondence connected with the work of PhD students, nominally registered with them, but actually working full-time in the National Physical Laboratory (NPL), National Chemical Laboratory (NCL) or Indian Institute of Commerce and Trade (ICT).

Today, the CSIR system is a parody of what it was supposed to be. It has lost sight

of its original objective and mission. Inertia, sloth and nonchalance are a hallmark of its laboratories. There are CSIR scientists who guide 50 and even more PhD scholars each, in effect mocking at the very meaning of the words “teacher” and “student”. Some laboratory directors and deputy directors routinely append their names to papers published from their institutions whether or not they contributed intellectually to the work.

Many CSIR scientists have become informal partners in small industries near their laboratories and it is anybody’s guess what work is going on and where. Most serious Indian industries, however, do their own work or import technologies. They do not work with CSIR perhaps because they suspect the quality of the results obtained in its laboratories and/or the levels of confidentiality that are maintained there. Barring a few honourable exceptions most of the 37 laboratories in the CSIR system may be safely wound up. The major asset they now have is the real estate on which they are located, and I would like to suggest that the government sell them off for whatever they attract from the marketplace. Perhaps large corporates may like to convert them into R&D centres. Krishna Kumar (2008) in his recent article on ICSSR, in this journal, has suggested that it be scrapped. My suggestion regarding CSIR is a parallel one and is made for roughly the same reasons. It is an organisation that has become redundant in the modern context.

Research Institutes: Some of these are actually deemed universities, and the most important one among this latter category is the Indian Institute of Science. Other institutes are funded by the department of science and technology (DST), department of bio-technology (DBT) and more intriguingly by the department of atomic energy (DAE).

A few among these are small enclaves of privilege that seem to be curiously unaffected by the maelstrom outside their walls. In all these institutes, there is little to no BSc or MSc level teaching going on. In the sense that they are not as large as the CSIR laboratories, they can do less overall damage but I supplement Krishna Kumar’s suggestion and will state that all

these organisations, except those that are engaged in strategic and defence research, be converted into universities and be asked to engage in full-time teaching along with their research. Government departments like DST, DBT and DAE have no business running scientific institutes in the same way that government departments do not need to run hotels, airports and factories.

Central Universities and the Indian Institutes of Science Education and Research: I believe that the university system is the principal organ that should be involved with all aspects of fundamental research in the country. In this regard I am supportive of the points made by Krishna Kumar. The NKC (2006) has elaborated on this idea extensively. It has suggested the formation of 50 new national universities. It is more guarded about the state of existing universities.

The central universities are small in number. Some of them are historically important and have seen better days (Delhi University, Banaras Hindu University, Aligarh Muslim University). Others have made their mark in the research scenario within a short time span (University of Hyderabad, Jawaharlal Nehru University) but remain vulnerable to political vicissitudes. The University of Hyderabad in particular has achieved an international stature in some disciplines. Others have tried to manage as best as they can in difficult circumstances (North Eastern Hill University, Pondicherry University). However, what is clear in the uncertain and unstable academic situation which now prevails in India is that the central universities provide better checks and balances for maintaining quality based on peer-review norms than do other institutions. The government has recently announced that three state universities (Goa and two others) will be converted into central universities and that it will establish 14 new central universities. This is a highly positive step but I believe that the numbers proposed are really sub-critical. The NKC projects that we need something like 1500 universities by 2015.

The recently formed Indian Institutes of Science Education and Research (IISER) are comparable to the central universities

in their general aims but there are important differences. For a start, these institutes are being branded as elite from their very inception and this distinction between “elite” and “the rest” has been the bane of our scientific and academic life since 1947. Secondly, the entrance examination for the IISERS is the IIT-JEE. Apparently the hope is that the lower ranked students, who cannot get into the IITs, can be “persuaded” to join the IISERS after “counselling” which also extends to the parents! This, in my view, is not good because it perpetuates the second class status of science with respect to engineering in the minds of students. Thirdly, the number of IISERS (five) is exceedingly small given the magnitude of our problem in science education. China is developing 100 science universities with an outlay of roughly Rs 100 crore per university per year. Fourthly, the IISERS teach only the science subjects and this too is a limitation. A really effective university must be able to teach all subjects.

I will reserve my final comment on the IISERS till I see what their students do after they complete their first degree. I suspect that most of them will go to the US or to Europe for their PhDs and be lost to the country after that. In this respect, the IISERS will only be following the route taken by the IITs. It is no secret that the IISERS are inspired by the IITs and are using them as role models. I have already commented above about the deficiencies of the IIT system. All of us make mistakes, but only fools repeat others’ mistakes.

State Universities: These are the whipping boys of the entire academic system. I agree with the NKC report which states that “the quality of education at most universities leaves much to be desired” and

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that “the number of places for students at universities is simply inadequate”. Enough has been said elsewhere about the sorry state of our state universities and I am not going to repeat that. Even the few universities that were doing respectable research 20 years ago (as examples only I will mention the universities of Pune, Jadavpur, Panjab and Madurai Kamraj University) have become pale shadows of their former selves. The central government must step in directly into the reorganisation of the entire state university system. We will have to address the problems that our founding fathers avoided in 1947 and reform our state universities.

This problem will not go away just because we refuse to acknowledge its existence. For a start, political interference in the appointments of vice chancellors must stop, and corruption in the administration, especially where it concerns faculty appointments, purchase procedures and contracts, must be dealt with harshly. There is a Russian proverb which states that even if a ditch is very wide it can only be crossed in a single leap. Never were truer words spoken.

I will still persist with the notion that the state university system must be restored to good health for the following reasons: (i) There is no way in which we can even begin to approach the NKC targeted number of 1,500 universities by 2015 without including the 325 or so state universities; (ii) In the university system the students can study all subjects. There is a very real need that students of science should have a basic grounding in the humanities and social sciences. This is not possible in the IISERS or in the research institutes. In particular, the need for a working knowledge of English is now deemed to be absolutely essential for anyone who is aspiring for a scientific career; (iii) The state universities have a very precious asset that is not available to the newer institutions, namely, the prime land they are located upon, and their very solidly constructed premises. The NKC (2006) suggests that they create resources by selling a part of this land. I will not be so cynical. Having worked all my professional life in a university which is located very far from the centre of a big city, I have realised that students, faculty and all those

connected with a university like to live close to habitation. This is a basic human need. We have too many new universities with substandard ad hoc buildings in far flung campuses. Once again, this perpetuates the “we” versus “them” divide and delinks academia from the society it is supposed to serve; (iv) The idea that the problems of an old university can be solved by creating a new university is basically unsound. There are universities like Cracow, Bologna and Oxford that are 1,000 years old. The Ivy League universities in the US are close to 300 years old. This is the norm in the rest of the world. In no other country do we have so many floundering universities, most of which are less than 50 years old. This reveals a basic defect in the way in which we are approaching higher education in this country. There is much to commend the adage “physician, heal thyself”. We need to sit back and introspect, and that too rather deeply.

4 Administration and Bureaucracy

For reasons of brevity, I will not go into detail but there is a widespread agreement that our administrative and bureaucratic set-up is suffocating in the extreme. The NKC (2006) speaks repeatedly about changing the entire administrative apparatus within universities. It asks for an Independent Regulatory Authority for Higher Education (IRAHE) which will effectively take over some of the functions of the University Grants Commission (UGC). However, given the Indian mindset, the IRAHE, even if it comes into existence, will become a clone of the UGC and academics will have to approach two refractory bodies instead of just one.

If we increase the number of universities to anything close to the NKC target of 1,500, it is clear to me that we will have to move away from a centralised system we now have to a decentralised system. Each university should become self-governing, autonomous and with the authority to seek its own funding. Appointments of vice chancellors should be internally driven by the faculty (even if the person appointed is from outside the university). There is no necessity for the president of India or for the governor of a state to tick a

name on a list so that a vice chancellor of a university may be appointed. There is little need for committees of wise men from outside the university to decide the important issues of the organisation. Particularly galling is the domination of the executive councils by external members, who are often hand-picked favourites of the vice chancellor; this is an anachronism that has no place in a democratic set-up. The ultimate executive authority of a university should rest exclusively within its faculty members. Self-help is the best help.

The science bureaucrat is an unusual creature who has propagated largely within this country. This species is largely unknown outside India. This entity comes in two sorts. The first is a PhD who is employed by a scientific department in his early years and works his way up the bureaucratic ladder. The second is a working scientist, who moves into administration while maintaining that he continues to be actively involved in science. Both varieties of this strange species have done incalculable damage to our scientific fabric. Let us consider each of them in turn.

Incalculable Damage

There is little that distinguishes the first sort of administrator from a government babu in a non-scientific department. He exists only to justify the existence of the department. He might be needed to implement government programmes that deal with societal and strategic scientific needs but he is not required in the implementation of educational and research programmes. Scientists and teachers can do this quite effectively with minimal support from administrative assistants. The NKC has recommended a National Science and Social Science Foundation (NSSSF) which is supposed to take over some of the functions of DST and DBT. It appears that the US-based National Science Foundation is the model for NSSSF. However, India is not the US and I fear that the NSSSF will become a clone of the DST or DBT in the same way that the proposed IRAHE might become a clone of the UGC. The answer, I feel, is not in more centralised bodies but in greater decentralisation. Apex bodies have never worked effectively in India.

Small is indeed beautiful, as Gandhiji never tired of saying, and we should adopt some of his convictions in the administration of our academic institutions.

The second sort of science bureaucrat is a scientist who has performed at a better than average level (when compared to his peers within the country), has been richly decorated with all the awards and recognitions that the scientific establishment of India can offer and moves as the top administrator of a university, CSIR laboratory or institute while in the age group of 45-55 or so. The value system that pervades the country today is one which places a high premium on administrative authority, but I am still surprised that so many otherwise competent scientists crave for these administrative positions so unabashedly. In no scientifically advanced country do top scientists prefer to take up administrative positions. In fact the converse is true, and such a move is usually greeted with amusement, or sometimes even derision, by the person's scientific peers.

It is a measure of our immaturity as a society that we believe an administrative position to be the acme of one's professional life. The problem does not end here. After achieving such a position, the leader insists that his or her scientific capabilities have not been impaired; in fact he/she often claims that he/she is doing better science after becoming an administrator. In actuality, the person in question does neither science nor administration very effectively and the organisation falls into decline and disrepute. Decentralised administration would provide a dampener to these sorts of activities, and while the administrator would be given his proper due, no one would mis-identify him as a great scientist, which is what is happening today.

Non-Governmental Involvement

In the end, we will not be able to dismiss the role of non-governmental agencies in the education and research sectors. There is no way in which we can achieve the NKC target of 1,500 universities by 2015 unless there is an across-the-board involvement of government, the private sector, individual benefactors and foreign organisations. We should learn to be more open minded

about non-government involvement in education. The government descended from the commanding heights of the economic sectors after 1991. It is time that it began a similar retreat from the commanding heights of the educational sector. Already, there is disturbing evidence of what happens when one fails to read the writing on the wall. The sharp increase in coaching classes, non-accredited universities and colleges, in fact all kinds of ad hoc and dubious arrangements that hawk and peddle education are very common now and indeed quite popular. The country is losing an enormous amount of foreign exchange in terms of fees paid by Indian students who are studying abroad. It is better if we think about the entry of foreign universities into India today and properly regulate such activity rather than wait for a time when their entry becomes unavoidable and under terms and conditions that are disadvantageous to the country.

The greatest damage that the administrative and bureaucratic set-up has inflicted is that it has degraded scientists to the point where they are unable to recognise quality anymore. Any repressive administration forces individuals to compromise. We Indian scientists have made so many compromises that we are now unable to even recognise that we are mired in a vast bog of mediocrity. After 80 years of puffing ourselves up, India is today unable to qualify to play hockey in the Olympics. But the rot had set in 20 years ago, with the administrators of the game mostly to blame, and we were in a state of denial – unable to recognise it, or too scared to recognise it, or too corrupt to want to recognise it. In the end, the exact reason does not matter. Academics kept silent in front of administrators for too long in a country that has stubbornly refused to identify and encourage quality. Disaster was inevitable and it is now a reality. In all successful countries, quality is a prized attribute. Because of this almost wilful neglect of quality India is paying a bitter price today in the field of education and research.

5 Looking Outwards

Like the Olympics, scientific research operates with an international currency. In such a regime it is difficult to hide warts

and blemishes and most scientists in India will freely admit that the standard of our research has miles to go before it attains top international levels. The comparison with China is especially painful. In 1980 China produced far less scientific publications than India. Today it has outstripped India in both quality and quantity.¹ However embarrassing it may be, we need to constantly calibrate ourselves against the standards set elsewhere. Publishing top class scientific papers is very different from launching rockets and missiles or exploding atomic devices. The Indian media have misled the general public in clubbing together all kinds of different scientific activities. In the end, missile technology is not high class cutting-edge science; rather it has to do with a proper and efficient implementation of technologies that were developed 20 or even 30 years ago in foreign countries. The launching of yet another missile, while laudable from a developmental and societal viewpoint, is no proof that we are doing state-of-the-art science.

We need to look carefully at the Chinese experience. They decided fairly early that high levels of student participation at the undergraduate level are essential. In turn, such high levels of undergraduate enrolment demand high budgets. China has

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opted for this route and has set up 100 universities each with a budget of around Rs 100 crore per year, and each handling 10,000 students [Desiraju 2008]. This would amount to an outlay of Rs 10,000 crore per year but nearly 3,00,000 students would graduate every year, and this is no small number. I do not believe that a sum of Rs 10,000 crore per year for undergraduate science education is large given today's realities (the DAE gets roughly Rs 7,000 crore every year) but there is a total lack of political will to take such a decision and what has been done so far, say the IISER exercise, is too little too late. Training a large number of science undergraduates is scientifically pragmatic, politically inclusive and strategically timely. I do not see that we even have an alternative.

We need also to think in terms of greater involvement of the Indian scientific diaspora, who are very often quite anxious to contribute in whatever way they can to improve the science education and research programmes within India. Also desirable would be moves to permit foreigners to take up employment in our universities [Desiraju 2008]. Disparate countries like the US, Switzerland and Taiwan have benefited greatly by throwing open the doors of their academic establishment to foreigners. The NKC goal of 1,500 universities by 2015 is no small matter. Where are the teachers who will staff all these universities? Clearly they are not all available in India. Shunning foreigners from our academic institutions is a xenophobic reaction that does not suit a country that is attempting to enter the global arena in so many other areas – taking over large international companies, organising highly lucrative cricket leagues, having the most profitable movie industry in the world and so on. It is projected that India will be the third largest economy in the world by 2050. The academic sector should learn to think big, if only to keep up with the rest of the country.

6 Looking Inwards

I finally take up the matter of caste reservations in academic institutions. This has been such a volatile topic, politically speaking, that very few have dared to address it directly. However, it is also true

that no discussion on education in India will be complete unless a disinterested debate on this matter is initiated. The NKC has made a welcome departure from the previous silences of the academic community on this topic [NKC 2006]. It states very correctly that “reservations are essential, but they are only a part, and one form, of affirmative action”. It goes on to add that “disparities in educational attainments are related to caste and social groups, but they are also strongly related to other indicators such as income, gender, region, and place of residence”. I will go further. The main reason that caste reservations have become so controversial is because there is now a firm feeling among groups who are not covered by these reservations that they are being deprived of educational opportunities because of these very reservations. In the end, no one is particularly happy. The truly underprivileged still have a long way to go and have not fully enjoyed the benefits of reservation while the so-called advantaged classes now feel totally excluded and even discriminated against. A backlash reaction from them would lead to civil unrest. Ironically even the political netas are a dejected lot with the latest Supreme Court ruling on the creamy layer. Of course, this is a problem that is largely the creation of our netas. All they thought about were vote banks. The solution also lies with them.

In my view, the solution is rather simple. The caste argument has become so polarised because there are simply not enough places for aspiring students. It is a scarcity issue. If massive amounts of money are infused into undergraduate education, so that basically anyone who wants to study is given a place to study close to his or her home, much of the heartburn would go away. Problems that can be solved with money are often the easiest problems to solve, and with the rising prosperity levels of the country, I am hopeful that the entire issue of reservations will rapidly become a ghost of times past. Most young people in this country do not want to join an IIT. All they want is a decent basic education which leads to a decent employment close to their homes. The government needs to phase itself out of the entire business of higher education and research, in the same way that it came

out of the economic sectors and the license-permit-quota raj.

7 Conclusions

The present scenario in the science education and research sectors is not good, and there seems to be little cause for cheer if all that is attempted is incremental innovation. However, and as a scientist, I will say that some of the biggest problems in science have been solved with audacious simplicity. To summarise, the government should involve itself less in the day-to-day running of science and scientific establishments. It should restrict itself to broad policy questions with societal, strategic and humanitarian implications. The university system should be re-established as the primary agency where all the teaching and fundamental research is carried out.

Elite institutions are the icing on the cake. It is silly to talk about the icing and revel in it, when there is no cake and even no bread. Very questionable are the plethora of scientific agencies and organisations wherein there is much duplication of effort, wasteful expenditure, little quality output and no accountability. Education is the continuous thread that runs through the fabric of all kinds of creative scientific activity. It is a right at the basic level and a privilege at the higher level. No one, student, administrator, or teacher should be made to forget this.

NOTE

- 1 “The bottom line in this comparison is unmistakable. In 1980, India was light years ahead of China in volume and breadth of published research. For two decades, India's research output production stagnated. During that period, China's research production increased exponentially. Presently, China outperforms India substantially both in quality and quantity (as measured by the impact factor of research output). The gap is widening and shows no sign of abating, if present Indian research policies are continued!” R N Kostoff et al, *Technological Forecasting and Social Change*, 74, 2007, p 1609.

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