

Mathematics in the post-independence India¹

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India will soon be celebrating its 75th anniversary of Independence which is a good occasion to take stock of how we, as a nation, are doing in mathematics. This also involves thinking of the profession of Mathematics, and the changing scenario in it, which I touch upon in this article.

At the time of Independence, India had very little infrastructure in terms of scientific institutions, and our first Prime Minister, Pt. Nehru, rightly emphasized science and technological institutions to be the modern temples of the country. Thus the IITs, the Central universities, TIFR, IIMs, AIIMS, BARC, NPL, PRL, ISRO etc. were setup in the first decades of Independence. Some other institutes which had started functioning before Independence such as the Indian Statistical Institute (ISI) and the Indian Institute of Science, Bangalore (IISc), were recognized: ISI as an institute of national importance in 1959, and IISc as a “deemed to be university” in 1958.

Many of the aforementioned institutions have done very well and are among the most important institutes the country has for science, engineering, medicine and management, and are the coveted institutions every student of the country aspires to go to.

India is a very large country and with the setting up of these institutions, although India made a good beginning, they were by no means adequate to cater to the many millions of students finishing the 12th standard each

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year. Keeping this in mind, in the first decade of this millennium, Indian government tried to enlarge the existing IITs, IIMs etc. to many more so that each state had one of each of these, and also created more central universities, and created IIT-like institutions for sciences: the Indian Institutes of Science Education and Research (IISER), which are there now in 7 cities: Kolkata, Pune, Mohali, Bhopal, Thiruvananthapuram, Tirupati, Berhampur, and are, in about a decade-and-half of existence, already well-recognized for their quality.

I myself grew up in the post-independence India, and when I was growing up in the 70's, there were very limited opportunities to pursue careers in science and technology in the country, and almost nothing outside these. In my youth, most students looked for jobs in banks, or civil services. Going to IITs was starting to become popular. Of course, the IITs have grown so much in their importance now that they offer the most coveted admissions in the country, and for which every year more than 2 million students appear in what's known to all students (and their parents!) in the country as JEE (joint entrance examination), selecting about 20 thousand students for the IITs, thus about 1 for each 100 student appearing for the examination.

But the India of today has changed considerably from the India of my youth. There are many more opportunities for young students to pursue many career options, including mathematics. Of course, here I talk only about mathematics which can be pursued at many of the institutions mentioned above, as well as at the Chennai Mathematical Institute (CMI), after finishing the higher secondary grade (12th standard). There are programs to complete undergraduate (BSc degree) in 3 years in most places, but now more and more places are offering 4 year undergraduate programs (so that students can go to USA more easily!), and then there are also many places having 5 year integrated BSc-MSc programs.

Although the number of the *top talents* of the country taking up mathematics in these undergraduate programs compared to the available pool of talented students at the 12th standard, is minuscule, it is not insignificant, let's say a few hundreds to a few thousands each year, depending on where we put the bar, who are quite good to excellent (so we are reduced from a billion plus population to a few thousands!). However, these

students in the undergraduate programs in Mathematics are spread over the length and breadth of the country, and except in some places such as ISI and CMI, the number of good students may be only a handful. The best students from these undergraduate programs by and large choose to go abroad for which many excellent opportunities exist, leaving very few of the most talented undergraduates in the country to go for a PhD program in mathematics in the country. Of course, some of the students who go for a PhD abroad do return to the country — and such numbers have been increasing in the recent past, but most do not come back, and thus India is steadily exporting excellent mathematics students abroad which should be visible to all.

India is a country which has had a considerable presence in mathematics, not only because two of the greatest mathematicians of the 20th century, Srinivasa Ramanujan and Harish-Chandra, came from India. But we have had a host of other distinguished mathematicians in the post-independence India, many from the Tata Institute of Fundamental research which has towered over Indian mathematics after independence with all the 3 Fellows of Royal Society the country produced in mathematics coming from there, and another one who became an FRS after going abroad having been at TIFR for many years. Till recently, all the invited speakers in the International Congress of Mathematicians (ICM), at least in Pure Mathematics, have come from TIFR. Last time, in 2018, Ritabrata Munshi of ISI Kolkata, and this time for the 2022 ICM, Neena Gupta of ISI Kolkata and Mahesh Kakde of IISc, Bangalore are the invited speakers who do not come from TIFR. While all the three were trained at the Indian Statistical Institute (ISI) for their undergraduate degrees, two of these three got their PhD abroad and also did some post-doctoral studies before returning to India, whereas one is indigenous. Although one cannot read too much from this sample size of three, it is indicative of many things, including that good mathematics is happening in many places in India now.

I now want to make some comments on the dynamics of mathematics as a profession. Popular perception considers it for the most part a solo activity needing only pen and paper to do mathematics. Nothing could be farther from the truth, unless you are a Ramanujan. For younger students

at least till the time they finish PhD, and then also for many years as professional mathematicians, they need to be immersed in an atmosphere of intense intellectual activity with peers as friends and competitors. A young faculty member joining a department in which she/he is the only one in nearby topics, is certainly going to feel lost or lose momentum at times whereas being surrounded by colleagues in related areas can bring her/him back to research. One knows of many examples of distinguished mathematicians who quit normal academic life: teaching, research, students, visitors, seminars, conferences, dinners (yes, that helps a lot to do research!), and the associated social aspects, hoping to devote themselves more fully to research, but never coming back to it.

I know of many departments of small as well as large faculty who have not much common interest, and no one can talk to each other on the subject which has brought them together; it is clearly very undesirable. Rather, it would be much better to have all the faculty in one subject, certainly another extreme. For example, at one point, Harvard specialised in Algebraic geometry and Number theory, *everyone* in the world who was *anybody* in the subject had to pass through Harvard! In fact everyone in Algebraic geometry and Number theory was at Harvard either as a student or as a post-doc or as a visiting faculty or as a permanent faculty, some in all roles such as David Mumford. And they did this with a faculty size of just 15 or 20, running both the undergraduate and the graduate programs!

The world of mathematics is becoming more and more competitive in the last 30 years (since the Chinese started to come in mathematics in a big way). Now even to get invited to a good international conference as a participant, and not even as a speaker, in one's own subject, not to speak of larger all-purpose conferences such as the ICM, is no mean achievement — department heads should pay attention to grant leaves to such people! What used to be middle level journals in the 80's and 90's (say below first 20 but in the top 100 in MathSciNet) are already becoming quite difficult to reach, and now a publication in such a journal calls for a celebration for the individual as well as for the country. Just to look at numbers, every year, there might be about 10 thousand papers being published in these top 100 journals (according to the MathSciNet MCQ), and my rough estimate

is that only about 50 of these papers may have an author who is in India. One measure of where we belong is how many of us (based in India) are in the first shortlist (say of a few hundreds) for a Fields medal, and I would not hazard a guess to disappoint you! It will be curious to compare how India fares in mathematics (or, sciences in general for that matter) with how it does in Olympic games, or the Olympiad programs.

Mathematics is also becoming increasingly compartmentalized. In most cases, Algebraists or Algebraic Geometers or Arithmetic Geometers cannot talk to each other. Not only that, even in their own subjects, they can talk to people of only certain interests. Different areas in mathematics have different cultures and these affect departments where they might be together. And for the departments, judging of individuals often gets reduced to the grants and awards/honors the individual brings, and the impact factor of journals where the individual publishes, without any regard to the quality or depth of what the individual does. It is clearly undesirable even if there is no obvious way out. The problem is compounded especially as everyone seems busy writing papers but no one is interested in refereeing papers (why should they!), and many of those who do, do a very perfunctory job. Thus both top journals and those considered not-as-good journals have a spectrum of quality depending mostly on the job the referees and the editors do – not to speak of their biases and preferences, and then if you hire someone based on a top journal publication, how fair are you to one whom you do not hire.

One of my friends, a director of an IISER, used to periodically ask me, “How many crores are needed to get a paper in the Annals of Mathematics,” as he was willing to make any investment to get his institute on the world map of mathematics (and had identified a bright young faculty whom he wanted to encourage). I had no answer (and I did not give him a false hope!), as getting a paper in the Annals is the end result of a long journey in which the country needs to invest in training many talented students hoping that one of them will make it to the top. Perhaps my response should have been a question to this director, himself a distinguished scientist, as to what he thought is the money needed to get a Nobel prize for India in science (which the country has not got since independence).

Back of the envelope calculation would show that India must spend instead of present 0.6% of GDP to at least 1% of GDP in higher education (to match other countries, for example China spends 2.1% and USA 2.7% of their GDP, see²) for next 20 years, and then hope that *perhaps* someone in India gets a Nobel prize. This comes (at the present 3 trillion dollars GDP – a figure that every Indian knows these days!) to an extra budget of about 12 billion dollars each year for at least next 20 years to get us a Nobel prize! Of course, we can wait for a Ramanujan or CV Raman to be born again, but even more importantly, hope that they do not go away to the West for better opportunities.

On the other hand, the support needed to run good activities in mathematics is considerably less. For example, the National Center of Mathematics (NCM), a joint venture of IIT Bombay and the TIFR has a budget only of a few crores (rupees!) and supports all kinds of undergraduate and post-graduate training programs in the country, but still has to fight for getting the financial resources. National Board of Higher Mathematics also has only a minimal budget to support undergraduate and postgraduate students in mathematics. Chennai Mathematical Institute is perpetually fighting for its survival. Many other centers of mathematics, such as Kerala School of Mathematics (KSOM) or Bhaskaracharya Pratishthan in Pune seem to survive on a shoe-string budget. The Indian Mathematical Society (IMS) has acquired a piece of land in Pune to house its headquarters, but has no money for constructing one, or to run any activity! I hope the country invests in mathematics — which means training of mathematics students from young students going for the Olympiad programs to those in the post-doctoral years, and those in faculty positions who do not stop to do research for paucity of funds for travel or to attend conferences. Going to conferences is not a luxury trip, it is essential to do sciences, where you not only learn the latest on your subject, you make contacts, so essential in any human endeavor. It is important to get out of our comfort zone at least once in a while and talk to our peers, juniors as well as seniors. For us in the third world when most of the sciences is done elsewhere, it is even more essential so that we do relevant research at the forefronts.

²<https://www.brookings.edu/wp-content/uploads/2019/11/Reviving-Higher-Education-in-India-email.pdf>

Most of the Indian students belong to the University system (India had just about a score of universities at the time of Independence, and now about a thousand). It is imperative that the University system be improved, and especially those doing well, are supported better. Students in the country with inclination to mathematics need to be connected better through mathematical activities, perhaps through the existing programs of NCM, NBHM, MTTS, etc. For this to happen, we must strengthen these agencies considerably with more generous funds. The mathematical societies, such as the Indian Mathematical Society and the Ramanujan Mathematical Society, should have more activities both national and regional, and should have a larger national presence.

I hope mathematics can be a serious career option for some of the most talented in the country, and that they try to reach greater and greater heights in mathematics, so that India continues to be a presence in mathematics, which is not easy as Lewis Carroll says in “Alice in Wonderland”:

*It takes all the running you can do, to keep in the same place.
If you want to get somewhere else,
you must run at least twice as fast as that!*

I want to end by making a case for the country as working and living conditions offered by many of our Institutes are excellent — perhaps even better than most places in the world, and salaries are good (in the Indian context, not to be converted to US dollars!). There seems nothing to prevent us from doing good work. But we are not doing so, except for some small exceptions. Most of us are not trying as hard as our counterparts in the Western or Eastern world. I would exhort students of Indian origin finishing a PhD outside India to consider coming back to India. India needs you and there are plenty of jobs available in mathematics. Your presence will surely make a difference to India!

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