

Report on the 2014 Platinum Jubilee Lecture Tour of Nitash P. Balsara
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I was privileged to be the 2014 Platinum Jubilee Professor of the Indian Academy of Sciences. I visited several Chemical Engineering departments at academic institutions scattered across the country between the dates of November 10th and November 24th, 2014. These included RGIPT Raebareli, NIT Calicut, NIT Surathkal, SJCE Mysore, and BMS College Bangalore (institutions I had not visited previously, that are working on increasing their research activity-I will refer to these institutions as Group A for simplicity), and IIT Bombay, IIT Kanpur, and IISc Bangalore (research-active institutions I was familiar with-I will refer to these institutions as Group B).

Instead of describing my experience at each institution, I thought it might be more useful if I provided a report on my collective impressions on specific topics

Before I do that, however, I will start with a description of my lecture provided by Professor Unnikrishnan of NIT Calicut: "The theme of his lecture was *Batteries, Biofuels and Sustainable Energy Landscape*. He highlighted that the traditional approaches for harnessing energy from fossil fuels might not be sustainable. Therefore, alternative approaches have been investigated across the globe. Conversion of solar and wind energy into electrical energy, utilization of hydrogen fuel cells and mimicking photosynthesis are some of the impressive strategies among them. The use of nanostructured block copolymer membranes in two applications of sustainable energy was explained by him. The membranes have been found to be ideal to transport lithium ions in polymeric lithium battery electrolytes and to separate biofuels from dilute fermentation broths. He also stressed the need for inter-university/ institute collaborations in this area." This description covers the important points of my lecture so I did not feel the need to rewrite it. I added a brief section on block copolymers for electron transport in lithium batteries in lectures given to some institutions. While this is essentially the talk I give when invited to US institutions, it was tailored based on input provided by Professors K.S. Gandhi, Ashutosh Sharma and Raghavan Varadarajan who organized the visit.

1. Students and Teaching

I begin with students as they are, without doubt, the most important part of any university. On average, the students at Group A institutions were much more engaged with the lecture than that those at Group B institutions. They appeared more interested in the topic, more interested in talking to me after the lecture, and they asked more questions. Some of the most thoughtful questions came from students at Group A institutions. The one I remember vividly was asked by a student at NIT Surathkal: "When you increase the free volume of the polymer in your biofuel membrane shouldn't the glass transition temperature decrease?" The question is extremely pertinent and one that we are currently investigating. I had not covered glass transitions in my lecture. It is remarkable that this student was able to connect a concept not covered in my talk with materials he was unfamiliar with (the materials I spoke about in the lecture had not yet been described in publications).

When I asked the professors about undergraduate students I detected a uniform difference in their response. Professors at Group A institutions were upbeat. NIT Calicut was delighted to have students from all across India, selected through the nationally held JEE. Kunal, the student who spent a few hours with me (he took me for a visit to a temple near Surathkal but what I appreciated most were discussions concerning his work on enzymatic reactions) came from Jamshedpur. I think that diversity of backgrounds of both students and faculty is important for all educational institutions. While many state colleges in the US like the University of California, Berkeley, where I work, have a local flavour, the diversity is what defines them. This increase in diversity in what were previously regional colleges is a new trend that must have been extremely difficult to nucleate.

All of the professors I talked to at the IITs were less than upbeat about undergraduate students. They told me that a large fraction of the students were only interested in the degree. High CPIs were desirable but only because they led to high-paying jobs in the banking industry or entry into IIMs. The reported fraction of uninterested students ranged from 80 to 95%! Professor Kunzru of IIT K, my undergraduate teacher who I respect deeply, told me that he just finished teaching his class and that not a single student asked a single question all semester long. While the Group B institutions were generally healthy, this might be something worth focusing on for improving their health. I suspect that in the long run, this will negatively impact the quality of education. To add fuel to the fire, Professors at Group B institutions also indicated that students are glued to their cell phones. Professor Rajiv Shekhar of IIT K told me of inviting two students from his class of 30 for a meeting in his office. The two students did not even know that they were in the same class! In this regard, the decision by IIT Calicut to not support wireless on campus seems like an interesting experiment. Students do have access to the internet but only through wired services.

Perhaps India should consider starting elite institutions with training relevant to the banking industry. If this were done, engineering professors will not be saddled with the burden of educating and testing them. Perhaps the JEE needs to be restructured to select students genuinely interested in engineering as opposed to those who are coached to get there regardless of interest. Many, if not most, appear to be burnt out by excessive coaching when they join. And as Professor Gandhi put it, if these are the statistics, some of the blame must lie with the professors who are not spending time on teaching.

2. Professors and Research

Most of the research-active professors in the Group B institutions were truly stellar. They are working incredibly hard to set-up amazing facilities like the battery-building facility at IIT Bombay built by Professor Mitra and colleagues, and the electronics fab facility at IIT Kanpur built by Professor Panda and colleagues. I was impressed by the drive and vision of these scholars. The true utility of such facilities will, however, require collaborations from people outside the battery and electronics communities. I trust that this will happen in coming years, and ensuring support for such high-risk high-reward collaborations will be vital. It was very nice to see the sustained output of the Nanoscience facility built some years ago at IIT Kanpur under the leadership of Professor Sharma. Individual meetings with Professors Sanjeev Kumar and S. Ramakrishnan (IISc), Rajdip Bandopadhyay (IIT B), and Yogesh Joshi (IIT K) were memorable. Perhaps this is because they described work on some of my favourite subjects: electrochemistry, polymer chain architecture, nanomaterials, and complex rheology. I particularly enjoyed it when research was described by students as arranged by

Professors Kumar and Ramakrishnan. It was also clear, however, that some of the young professors had not embraced the challenge of being active in both research and teaching. In the absence of a rigorous tenure system, finding ways to encourage them to work on research or changing the current system seems the only way out. Saddling such faculty with excessive teaching, a practice that is not uncommon in the US, does not appear to be in the best interests of the students.

I marvelled at the drive of the research-active professors in Group A institutions. For example, Professor Ojha of RGIPT is publishing superb papers on current topics such as responsive hydrogels in a make-shift lab in the make-shift college building while the RGIPT campus is being built. While on the subject, the superb leadership of Professor J.P. Gupta, under what are surely very difficult conditions, was entirely noteworthy. Similarly, the facilities and problems being addressed by Professor Prasanna of NIT Surathkal were extremely impressive. Finding vehicles to fund high class researchers at these institutions and fostering collaborations, first between colleagues at the same Group A institution, and then between institutions should be a high priority. Professor Ojha, for example, routinely travels to IIT Kanpur to use equipment there. I imagine that support for such activity is not easy to come by and perhaps, professors are using personal funds and connections to accomplish travel, lodging, etc. Amongst the teaching laboratories, I was struck by the Polymer Processing laboratory at SJCE. It was a remarkably well-run laboratory with modern equipment, excellent maintenance, and solid plans for improvement.

I also must remark that the leadership at all departments was impeccable. All of them were clearly looking out for the common good, they were leading by example, and they had the respect of the faculty and students.

The lack of involvement of the Indian industry in academics was a concern. While the research activity in these institutes may be far removed from the immediate needs of this cost-conscious industry, captains of Indian industry, many of whom were educated at the institutions listed above, might consider investing in the future of their alma mater. Surely there is some cost associated with ensuring that their employees are being trained by faculty aware of developments that are of current global interest (e.g. my project on biofuels which funds two post-docs, three PhD students, and 1 undergraduate is funded by the petrochemical giant, BP). Perhaps leaders of Indian industry and academia might consider a study of the industry-academia connections in Japan or Korea.

I met many outstanding faculty and students during my visit. The names left out of this report should, by no means, be taken as something negative. Including all of those interactions would make this report unwieldy, if it is not so already.

3. Accreditation and Evaluation of Institutions

I learned that Indian Chemical Engineering institutions were being subject to evaluation similar to the ABET system in the US. This is a system wherein a central body comes up with general methods for improving curricula based on many factors such as evolution of grades on a particular topic in a course, answers provided by students on a scale of 1-5 on whether they learned a particular concept or not, examines points scored by students on specific questions in tests, etc. I

think that it is very important to quantify facts as much as possible. This is standard engineering practice. If, for example, students are not learning important concepts, then teaching must change. But the surveys typically part of the ABET process are simply not scientific. There is no baseline. One student's 5 might be another's 3! One year's 2.6 might be another's 1.3. ABET-like bodies should continue to look for meaningful metrics to evaluate departments, but they should refrain from implementing measures until they are confident of the accuracy of their metrics. I propose that when there is no accurate metric, it is better not to use standard feedback control schemes to drive a system.

The main objective of a university education is learning the skill necessary to learn what is necessary; the particular concepts mastered are less important as fields evolve over one's lifetime. Given the track-record of impact of IIT graduates on world-wide technology development, research, and their forays into disciplines far removed from engineering, is difficult to argue that education at the IITs of the 1960s and 70s was not high quality. There were many exams during those days where getting 20 marks out of a 100 at IIT K was above average. In contrast, average scores were often very high if the same course was taught straight out of a textbook. I wonder what an ABET accreditor with a standardised definition of positive scores would have mandated had he or she come around in those days?

Quality of instruction depends on the integrity, creativity, and knowledge of the instructor. If your department has competent and committed faculty, they will teach the challenging concepts that underlie science and engineering. What distinguished IITs from all other scientific institutions of the day was the freedom given to faculty. Faculty designed the courses, tests, grading schemes, and outcomes. There were no board exams (the way most of the colleges in the country were operating) or boards examining instructors. In fact, we know now that our professors were so ahead of their times that there could not possibly be a governing body knowledgeable enough to help them make sensible corrections. I can attest that all through graduate school in the US, I felt I had an unfair advantage over students in my class, due to the rigorous training I had received at IIT K.

I think that it would be great if renowned and respected professors examined curricula in a particular institution and suggest topics, text books, and examples that, in their estimation, would lead to improved teaching. But the current ABET system in the US, however, seldom brings such professors to our institutions. When the ABET days arrive at Berkeley, we fill rooms (not desks but rooms!) with files to comply with the requirements. To my knowledge, after the last evaluation, my department was put on some-sort-of-probation as our compliance with student outcome-driven improvement was deemed to be low. We spent the next two years scrambling to comply with the mandates that came from up above. I was unable to detect any positive effect of this scramble on teaching. Streamlining the accreditation process so that renowned faculty would actually volunteer for the job is equally important. No research-active faculty will study documents in rooms full of files piled as high as possible.

What has not worked in the US may not necessarily work in India.

4. Concluding Remarks

India is clearly on the move. Optimism is in the air. There is something astir in all of the institutions I visited. Like all systems, they are not perfect and challenges remain. The space in this

report devoted to the challenges is large, not because the imperfections are large. This mainly reflects my inability to condense my thoughts. Overall, it was an amazing to witness the new horizons emerging in all of the institutions.

The institutions spared no effort or expense to ensure that I was comfortable and taken care of. I enjoyed the non-technical aspects of my visit, e.g. the trip to the mountains near Calicut and the visit to the wildlife sanctuary in Karnataka.

My sincere gratitude to all involved.