Pasteboard

I don't want to be a mathematician*

Actually things might be even worse: nobody wants to study physics or chemistry either. Or biology. Today's young Indian would rather be an engineer – again, not to do honest engineering, but to facilitate his entry into an IT firm, and, a little later, his gateway to a management degree.

It is only now that we are finally getting worried by this turn of events. If the next generation does not have competent mathematicians, then who will predict cyclones, rainfall and tsunamis? Who will devise better guidance and control systems for our missiles and aircraft? And who will come up with superior stochastic models for risk management?

I sat through a workshop on 'Perspectives and Future Prospects in Higher Mathematics' at NIAS for the best part of two days, and returned unscathed; perhaps because I enjoy the company of mathematicians. Most mathematicians, certainly most good mathematicians, are very unpretentious: they seldom wear three-piece suits, although they are quite likely to turn up with unkempt beards. They argue passionately about rather trivial things, and smoke many more cigarettes than they should. They are blunt, and rather truthful. M. S. Narasimhan, a veritable *pitamaha* of Indian mathematics, said at the end of the workshop: 'sometimes I worry that we assemble at such meetings simply to talk, and then go away without doing anything!'.

The NIAS workshop returned a generally gloomy verdict: 'pure' and 'applied' mathematicians are still at odds, the pure mathematician is still rather proud of his purity, and the applied mathematician is still rather envious of it. The teaching of mathematics, especially at the undergraduate level, is in shambles. There is precious little to entice a good teacher into a college math faculty (dismal wages, and rapidly declining social esteem), and this hapless math teacher, in turn, is woefully ill-equipped to entice a bright youngster into a mathematical career.

Even if a bright young kid should accidentally stray into the world of mathematics, his elders will ferociously dissuade him: 'do you want to become a software engineer with Google or end up as a college teacher in Gurgaon?'. Finally, that's the crux of the matter. The glitter of the lucre is overpowering.

So if mathematics is to be revived, you must make sure that the lucre glitters your way. Now that could indeed happen if this KPO wave were to hit India. With BPO, or business process outsourcing, the deal was: 'our brain, your brawn'. With KPO, or knowledge process outsourcing, it will be: 'your brain, your brawn, our money!'. And then our KPO merchants will discover that mathematics can provide the best 'value add' to the business. And then doing mathematics would suddenly become lucrative … and the best brains would come rushing in.

I see this as the only big hope. Of course our bureaucracy will still see things its way. They will say that mathematics can be revived by more generous funding: 'increase the Eleventh Five Year Plan outlay by a certain per cent, which will translate into an additional inflow of so many crores of rupees, which, in turn, will trigger off an upswing of a certain magnitude, etc. etc.'. I have seen a bit of this government funding business: and I now know that intent seldom works, but serendipity might still deliver.

The workshop also exposed the alarming chasm between the mathematician and the engineer. The mathematician (pure or applied) tells the engineer: 'just write down the governing equations for me and I will provide you the solution'. The engineer is confused: 'but I came to you only because I do not know how to write down these equations myself!'. In the end the mathematician finds himself out of the loop and the engineer often ends up making poor and ill-informed decisions.

This inability to communicate professionally hurts us much more than we realize. Denied a sophisticated or optimal mathematical solution, the engineer opts to buy a (very expensive) 'black box' which claims to embed the desired mathematical ingenuity. Soon he must buy a second (expensive) black box and then a third. Finally he cobbles together his product or solution which either delivers the desired performance (but he does not fully know how) or fails to deliver (he does not fully know why). A lot of India's R&D failures can be attributed to faulty management, but a significant proportion of failures, or non-compliances, are also because of poor mathematical acumen and even poorer inter-disciplinary communication.

The NIAS workshop also highlighted the need for inter-disciplinary research and interactions, and of the mathematical energy that it would unleash (Roddam Narasimha called it 'hybrid vigour'). Narasimha recalled the happy consequences of a series of unstructured meetings between scientists and businessmen that he attended for a few years around New York: 'while we scientists merely saw them as friendly interactions, the businessmen were exultant: you do not realize how many problems you have solved, they told us'.

So it is really rather worrying: the country clearly needs mathematicians, but no one (outside a measure zero set) apparently wants to become one. In fact, I once posed the following question to Narasimha: 'What if India completely eschews science and technology? There are so many countries who live, and apparently quite well too, just on trade, commerce and other economic instruments!'. Narasimha was first horrified by the thought, and then deeply pained. 'I just hope that never, never happens to India', was all that he could say.

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*Paul Halmos, the eminent mathematician, titled his 'authomathography': I Want To Be A Mathematician. Halmos passed away on 2 October 2006, aged 90.

exactly what the engineer finds hardest to do!'. 'Seek corporate sponsorship for mathematical events, and encourage young students to solve practical problems ... it is amazing how much they enjoy doing this'. 'I'm tired of hearing all our bigwigs saying that money is no problem; tell me where is this money? I have not found it anywhere!'.

The key refrain in the second panel's discussions on 'Applied Mathematics (Research, Training, Application)' was that applied mathematics was not 'ugly, dirty or messy', but actually 'fascinating and exciting'. *Roddam Narasimha*, JNCASR, talked of its richness and diversity, of how advanced computing techniques are bringing in a big change ('although the applied mathematician's lack of interest in computing bothers me!') and how the most interesting work is being done by those who have successfully 'crossed the border'; indeed, applied mathematics in India would gain immensely if it 'opened up' and allowed itself to be driven by the ensuing 'hybrid vigour'. *Prabhakar G. Vaidya*, NIAS, offered an intimate glimpse into his love affair with applied mathematics and succeeded admirably. 'When mathematics works, it works very powerfully', he gushed. Vaidya recommended 'opportunistic wandering' in mathematical territory, especially to engineers: 'when I now look back at my days as an engineer at Boeing, I realize how inadequately I was trained in mathematics', he remarked. *Phoolan Prasad*, IISc, pointed out that applied mathematics attracted even fewer students than pure mathematics. He seemed especially worried at the lack of leadership in the applied mathematics community. *S. Ranganathan*, IISc, Bangalore said that it was essential to create the right ambience for inter-disciplinary research: 'when it is possible to embed journalists in Iraq, can't we embed a few applied mathematicians in a metallurgy department?'. Ranganathan also said that we need to do more to 'communicate the excitement' of doing applied mathematics. *Anurag Kumar*, IISc, Bangalore gave some examples of the use of mathematics in electronic communication and said that industry and academia need to enter into a more meaningful and fruitful business relationship.

The following sentiments and ideas were articulated in the discussions that followed: 'Could the divide between the pure and applied mathematician be actually widening?' 'It would be worthwhile to look at the INRIA model in France where interactions at the highest level take place between mathematicians and engineers; initially the INRIA set-up had few takers, but very soon Airbus was running to them for help'. 'We need a "referral institution" for problems requiring mathematical solutions'.

The third panel on 'Higher Education in Mathematics' threw up a lot of practical problems and everyday concerns in the teaching of mathematics, and also some innovative advice and suggestions. *H. P. Dikshit*, IIITM, Jabalpur, who has a deep knowledge of India's university system said that the greatest attention must be paid to the teachers' welfare and orientation: 'out of the 60,000 or so mathematics teachers, at least 30,000 are contract appointments who get paid on a teaching hour basis'. He recommended an enhanced role, and higher grants, for the National Board of Higher Mathematics (NBHM), and also sought careful monitoring of the performance of academic establishments 'so that the best can be better rewarded'. *S. Kumaresan*, University of Mumbai, remarked that semi-urban and rural regions are likely to be the new 'catchment areas' for young mathematicians. He wondered if teachers are failing to project the excitement of watching mathematics 'in action'; and recommended interactive classes where the teacher can motivate his students to think creatively. He also asked the industry to support higher education: 'after all it is the industry that is enjoying the fruits of the higher education subsidized by the government!'. *A. Sitaram*, ISI Bangalore, said that pre-Ph D training was vitally important. 'Let us organize one-year training programmes in analysis, algebra, probability and topology at different centres in India so that the theoretical foundations of research scholars are sufficiently sound'. Sitaram said that we must aggregate scholars so that at least 15–20 of them attend the training programme: 'if we start with just 3–4 scholars, such programmes often fizzle out!'. *Shobha Madan*, IIT Kanpur, made a passionate plea to bolster the university system on a war footing 'because most future mathematicians will emerge from these universities'. 'We have issued a national call to save the tiger; let us issue another call to save the university!'. She said that both the curriculum and the examination system require a big change: 'let us look at designer courses that encourage specific mathematical abilities or applications'. Madan also said that a higher authority must take over a part of the university exams: 'we must ensure that at least 20% of the exam questions are clever or challenging; it bothers me that to pass math exams today, you only have to memorize a few answers from an exam guide!'.

The reactions to the panel's presentations were many and varied: 'Engage the real world; teach students how to apply the Fourier series – instead of only asking for its convergence criteria'. 'The Karnataka Cricket Board went to small towns and villages looking for cricketing talent; perhaps mathematicians should do the same'. But will they? 'Look at possible mechanisms to bring retired scientists into universities'. 'Offer students hands-on experiences'. 'Think of ways to encourage more women to participate in the teaching of mathematics'.

Madhavan Mukund, CMI, Chennai, initiated the discussions in the fourth panel on 'Computers and Mathematics'. He started by explaining the difference between IT and computer science: 'most of what passes as IT is routine repackaging of unsatisfactory products, while a computer scientist's endeavour is to solve problems efficiently, build tractable models and develop the best possible algorithms'. 'We need serious insights in computer science, not dumb hardware, to achieve the great leap forward in computing', he pointed out. *V. Vinay*, PicoPeta Simputers Private Limited, Bangalore argued that mathematics needs to be repositioned, and we must recognize that algorithmics is emerging as the new face of mathematics: 'it is finally all about computing; so let us teach students counting, induction, recursion or finite automata'. Vinay too sought to clearly define computer science: 'it is all about developing algorithms for machines ... I am horrified that so many believe that computer science is about what happens when you right click the mouse on a Microsoft user interface!'. *V. Arvind*, IMSc, Chennai, and *Satya V. Lokam*, Microsoft, Bangalore, made detailed technical presentations on issues in combinatorics and algorithmic complexity; perhaps more suitable for an IISc lecture hall than NIAS's J.R.D. Tata Auditorium.

Some of the reactions to this panel's presentation were: 'Either make mathematical teaching content exciting, or

downsize it'. 'I am appalled how people believe that all of computer science can be taught by using 'Learn Excel in a day!' type of books'. 'When was the last time we explained the pigeon hole principle to a school child?'.

The final panel discussion on 'Requirements of User Agencies' was flagged off by *R. L. Karandikar*, Cranes Software International Limited. He said that the perception that mathematics offers career options only in teaching or research is no longer true: 'as the BPO wave turns into a KPO wave, the corporate world will need a lot of trained mathematicians'. Karandikar recommended a Master's programme with courses in mathematics, statistics, economics, finance, computer science and programming 'that will go easy on rigour but focus hard on explaining concepts'. He also recommended major support for cryptography 'to fulfil major national needs in the defence and finance sectors'. *V. Adimurthy*, VSSC, Thiruvananthapuram discussed how space research provided numerous opportunities for applied mathematicians ('in orbital mechanics, multi-disciplinary optimization or three-body problems') and indicated that national R&D establishments required more mathematicians 'to bring in flair and innovation, and help in developing superior technology products'. *Guruprasad Athani*, Infosys, Bangalore, presented a case study in oil exploration, involving optimization of oil pumping rates, and explained how Infosys used mathematics to add significant value to what would otherwise have been a mundane IT project. Athani explained how the demand for mathematicians will grow even more as KPO proliferates ('so many people now ask me if I have people who are good at game theory') and predicted that applied mathematics will fuel most of the future technology successes. *B. K. Dutta* and *S. D. Paranjape*, both from BARC, Mumbai said that DAE needs many more mathematicians. They suggested the establishment of a national centre for computational mathematics with equal ('50 : 50') participation of mathematicians and engineers. *Debasis Chakraborty*, DRDL, Hyderabad also agreed that DRDO establishments are woefully short of mathematicians ('we encounter so many problems in computational fluid dynamics, partial differential equations, image processing and optimization that require mathematical skills').

The reactions expressed after the panel's presentations once again proved to be very illuminating: 'It might be a good idea for DAE, ISRO and DRDO to come together to jointly fund a new institute of computational mathematics'. 'Excessive specialization may be unnecessary; we really need just a good basic course'. 'Projects involving computational approaches are likely to get good support'. 'Do we, as a nation, have an insidious death wish? How can we afford to ignore mathematics?'.

Before the workshop's drafting committee adjourned to make its recommendations, there was a lively end discussion. *K. Kasturirangan*, Director, NIAS, expressed his happiness that the workshop had been so spirited and useful. He reiterated that the idea of setting up a multidisciplinary institute in computational mathematics merited serious consideration. He asked the national science academies to play a more active role in popularizing mathematics ('let every Fellow agree to mentor two young mathematicians'). He agreed that India needed good outreach programmes to enrich mathematical education. Kasturirangan also said that it was time to seize the moment: 'I know that both the Prime Minister and Finance Minister are very keen to support mathematics!'. *H. P. Dikshit* agreed that it was time for India to 'exploit the computation wave'. 'We must change the mathematician's mindset; build more centres to train mathematicians, and pay teachers more to raise their social esteem'. *Geetha Venkataraman*, St Stephen's College, Delhi said that undergraduate education was the crux of the problem. She gave a remarkably eloquent account of the 'ground reality' in university colleges: 'teachers are excessively taxed, students are unprepared for the curriculum on hand, and there are serious language and communication problems'. Recalling that 'as a graduate student in England, I had the privilege of being taught by the seniormost professors and researchers', Geetha Venkataraman lamented that in India we have this terrible divide between the hallowed researchers and the hapless undergraduate teachers: 'does anyone even think of these poor teachers, or care for them?', she wondered. *M. S. Raghunathan*, TIFR, Mumbai in his closing remarks, said that the paramount need appeared to be to improve the status of teachers. He asked if it was a good idea to introduce a teaching cadre ('rather like the IAS cadre') for teachers of mathematics. *B. V. Sreekantan*, NIAS, who worked quietly behind the scenes to arrange the workshop, observed that 'improving the living condition of teachers appears to be the key requirement'. The last word came from *M. S. Narasimhan*, TIFR Centre, Bangalore: 'sometimes I worry that we assemble at such meetings simply to talk ... and then quietly move away'.

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