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We publish below a commentary which is 'written in some anger'—a rejoinder to an earlier article which summarized the feelings of a number of young mathematicians as to how to improve mathematics education. The present article is associated with many mathematicians who have given much thought to improving teaching methods of mathematics in schools and colleges. The message is that, like in most fields, mathematicians too are divided; (The readers will be familiar with the controversy we are having between classical and modern biology); It is not desirable to characterize different aspects of mathematics—however much each devotee is partial to his own; What is really important is to nurture the 'natural flair' in a young student whenever and wherever it is found.

—Editor

Mathematics education—some remedies

M. S. Rangachari

The commentary 'Can we do something about our mathematics education?' by *V. S. Sunder (Curr. Sci., 1992, 62, 658–659)* overlooks the real cause for the sad state of mathematics education and advocates remedies based on vested interest. The signatories to the present commentary who are perhaps to be described as 'senior' mathematicians according to Sunder's commentary and who are perhaps not mathematicians of 'non-trivial' standing from such institutions as listed by Sunder, have, however, been involved in programmes relating to school mathematics, college mathematics and 'research' mathematics in the past four decades and have been invested, by the grace of Providence, with a concern for the students who take to study of mathematics besides mathematics itself.

The main points overlooked by Sunder's commentary are:

(i) Most of the Indian children have a great potential for mathematical thinking right at the start of schooling and even outside the school system irrespective of caste, creed, religion and region.

(ii) Mathematics is made difficult and uninteresting to children even at the primary level since it is mostly taught by a teacher with no aptitude for mathematical thinking, along with other subjects, much less with no capacity to make mathematics interesting.

(iii) Only one in thousand or even less master the techniques of mathematics taught at school (mostly computational) and equip themselves with a refinement of the skill of computation at the school-end level to face competitive examinations, where performance in mathematics matters very much, so as to get into professions which could provide them better career than that of a mathematician. The rest take to mathematics as a bugbear and are proud of declaring later in life after getting into positions that they treated the subject so.

(iv) Those who are destined to graduate or post-graduate in mathematics, take to these ventures left with no other better option and that too within a system of lecturing-learning for which no concern is shown by the lecturer, the syllabus or curriculum framer and the authorities who institute the system. In the name of updating of the syllabus, mathematics at post-graduate level has been made memory-oriented theorem-proof subject, killing the remnant capacity for computation left during graduation.

(v) So-called mathematicians of 'non-trivial standing' do not show any concern for the ills of the system either singly or as a group. Having defined 'non-triviality' by themselves, they show interest in declaring others who come up in spite of the system as 'trivial' or 'non-trivial' with the sole aim of multiplying their species with the least regard for the country's needs and its potential. We are aware that most of the mathematicians of 'non-trivial' standing consider it against the interest of their own original work to take interest in making moves to make the existing system meaningful or to evolve a new system to serve even their 'non-trivialities'.

Let us elaborate a little on the above issues:

(a) Some of us are involved in a project conducted by the Association of Mathematics Teachers of India and sponsored by the Ministry of Human Resource Development, Government of India, on identifying innovative teaching-learning methods for the improvement of school mathematics. This project is done through workshops at the levels of primary, middle, high, higher secondary school in the several regions of the country with participation of both teachers and the taught. Two of the workshops at the first two levels have revealed to us that a majority of children enjoy learning mathematics whether it is computational or conceptual provided it is presented in terms of practical experience. They are able to think also by themselves on the issues presented and make their own inference. There is some resistance of teachers to these innovations (in which P. K. Srinivasan has done pioneering work). To hint at a few of them, dotted sheets could be used to illustrate g.c.d. of numbers, fractions and operations on them can be illustrated by paper folding. Learning mathematics through experience and practicals instills confidence for self-study and to take up small projects in

children. The mathematics-phobia in them is got rid off this way.

(b) Till school-end level (up to 12th standard) in the present system children who are toppers have a flair for computation. Conceptual aspects of mathematics such as continuity, limit, group, etc. are not so well understood by these children. Mathematical educators like R. L. E. Schwarzenberger and D. O. Tall have shown, in fact, how calculus cannot be made easy at school. In the name of introduction of abstraction useful elements of mathematics such as tracing curves or drawing graphs, the proof of most of the results of euclidean geometry, etc. have been given a go-by by the syllabus framers who were either mathematicians of 'non-trivial' standing or were admirers of this brand among the 'trivial' ones. Possibly, they thought that our school children should appreciate Klein more than get geometric intuition. Even those who have no other option than to do their B.Sc. Mathematics have more confidence in computing an integral or in differentiating a function than giving an example of a cyclic group. The syllabus framers at the B.Sc. level and M.Sc. level influenced by the 'non-trivial' brand are, however, intent on brushing this skill aside and prescribing a higher dose of abstraction resulting in learning by rote memory. Computation is 'triviality' for this brand of mathematicians while it is the computer which rules supreme in the rest of the world and mathematicians outside the country mimicried by this 'non-trivial' Indian brand have no hesitation to turn to computers at least under the garb of theory of computer science. Thus natural talent is ignored while artificial talent is sought for from youngsters because of vested interest. A fine opportunity for our graduates and postgraduates learning mathematics with its influence and interaction with the computer has been lost because of the indifference of a brand of mathematicians who care for what they are capable and do not care for the future of the youngsters who are forced to take to mathematics after school.

(c) We are seriously involved in programmes of making certain themes in undergraduate mathematics firstly interesting to teachers at this level and then to their students. Mathematicians like Shriram Abhyankar have time and again stressed that even classical algebra taught at this level is quite important. Quite to their dismay there are mathematicians of the 'non-trivial' brand who discourage such programmes. It is pity that the enormous work by stalwarts in the past and the formidable questions left out to be considered by them do not make the 'non-trivial' brand humble. It is again a pity that every one in this brand poses to be a 'Hilbert'. Possibly, they do not hope to face a Godel to become mad! *What the country needs is not Hilberts but Kolmogorofs to go down to the school system, where there is potential, inspire young children, interact with them and make their potential blossom.*

(d) The present attempt to spot out talent at school-end level and to exhibit it in world contests is half-hearted. No agency wants to utilize the spotted talent for the development of mathematics. The excuse is that these students opt for technology for a career. No attempt is there to see whether they can be made to study mathematics conforming purely to their aptitude side by side with technology or to study applications of mathematics to technology or computer science and to interact among themselves to do creative and really original work of their choice in mathematics. Again, having spotted talent even for original work in some aspect of mathematics in a few youngsters, instead of nurturing such talent, the mathematicians of 'non-trivial' standing wish that the talent be in their 'non-trivial' themes and ignore or belittle the existing talent.

Let us now go into possible remedies for the situation.

(e) Existing mathematicians in the country whether belonging to 'trivial' or 'non-trivial' brand should have an open mind in making mathematics interesting to children and youth. If they cannot be appreciative of the need for making mathematics enjoyable, let them keep off mathematics education so that the young mind is not polluted by the poison of distinction of 'trivial' or 'non-trivial' mathematics and is not made diffident of taking to mathematics. Identifying institutions 'such' as TIFR, ISI branches, etc. as the abode of 'non-trivial' mathematicians is aimed at this poisoning of the young minds and should be immediately put an end to. It is a pity that the 80 young crusaders thought of for the revamping programme are going the way of 'senior' mathematicians of the 'non-trivial' brand who have alienated themselves from the mainstream. A populous country with lot of mathematical potential cannot just boast of a few institutions managed with vested interest and owing allegiance to foreign groups in the matter of deciding importance and usefulness of mathematical contributions in the country. We want a group of youngsters who have self-respect and are highly original and who do not consider tinkering with ideas of their foreign counterparts to come up and take charge of mathematics education and research.

(f) The creation of such a group of youngsters can be only through exposure of mathematics as an enjoyable theme right from school with projects involving original thinking and computation. Identification of teachers, mathematicians and mathematics-users who can take up this task on a war-footing without bias or prejudice should be given top-priority. The country can afford to wait for a decade if those identified inculcate a spirit of confidence in our children in studying and using mathematics and help in the blossoming of original thinking in them.

(g) Any thinking that the existing system of colleges and universities should be bypassed to institute study of non-trivial mathematics amounts to wasting the resources of the country. How exactly the existing system can be revamped has been discussed in the Report of the Curriculum Development Centre in Mathematics, University Grants Commission, 1989. Neither the universities and colleges nor the academics who man them have ever cared to look at these suggestions, not to speak of their implementation. The influential mathematicians who want to change the mathematical situation in the country should consider these suggestions, evolve better ones, if need be, and take the entire teaching and research fraternity into confidence for their implementation. No attempt to create a brand of mathematics will serve the cause of the country or of the subject.

(h) Making mathematics interesting at all levels of learning alone cannot make the youth take to mathematics as

a career. In a country with an orientation towards gaining more money and facilities, mathematical administrators, should not hesitate to recommend providing a talented youngster (with no requirement of 'non-triviality') a scholarship of Rs 2000 p.m. for continued interest in mathematics after school after proper checking of the development of talent and knowledge. With no strings about the choice of specialization a highly talented really original mathematician should be given a coveted initial position carrying Rs 5000 p.m. irrespective of his age. When enormous amount of money has been spent in special institutions to help 'non-trivial' mathematicians for the past four decades with an output of not more than a dozen such mathematicians during this period, the money spent in the Universities and Colleges during this period is a pittance. In the light of the lavish spending on these institutions no investment in an youngster with a promise for mathematical originality (in the objective sense without the tag of 'non-triviality') will be high or wasteful.

Let us wish for the sake of mathematical development in our country, that young mathematicians who have done good work and are gifted in making mathematics interesting and enjoyable to youngsters do not join the bandwagon of mathematicians of 'non-trivial' standing from 'such' institutions to create future mathematicians of this brand. Let those who need to be told by their peers that if Srinivasa Ramanujan was *not* a mathematician, then they were not, and who think that they are equal to Srinivasa Ramanujan himself, and even better than him, keep off misdirecting such young mathematicians..

The following have associated themselves with the above article: G. Rangan, S. Muralidharan, P. N. Natarajan, R. Bhaskaran and R. Parvatham.

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