Mathematics Education — An unconventional approach

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1. Introduction

Mathematics does not recognise any national boundaries; but that is not the case with mathematics-education, because it essentially belongs to social sciences. Thus mathematics education is influenced by the history, culture and traditions of the society. In this talk I shall dwell on mathematics education in relation to our Indian society.

Once we recognise this social nature of education, it will not be difficult to realise that in Indian context mathematics education stands on quite a different footing when compared to science education. Mathematics has a long historical and cultural tradition in India. In fact like classical music, dance, sculpture or sanskrit literature, it forms our cultural heritage. This long tradition of mathematics has led to an intrinsically Indian way of teaching and learning mathematics. Even before the introduction of the present-day formal school education there existed elementary (one teacher) schools in our country and mathematics formed an important subject there. Thus mathematics education, too, has a distinct tradition of its own

Ramanujan phenomena could only occure in India - Yes, Ramanujan is at the apex of a phenomena observed all over the county in which we find several ordinary people exhibitting mathematical talents. The secondary school teacher D. R. Kaprekar, the primary school teacher M. N. Khatri or the newspaper ~~vendor~~ vendor Pravinbhai Mehta are representatives of that phenomena whom I have come across. The existance of such a phenomena is a proof (if any proof is needed) of long tradition of learning and teaching mathematics in our country.

In this talk I plan to discuss mathematics education in our country keeping this cultural haritage in the fore-front.

2. Elementary Education

A universal (as opposed to social or local) trait of this "Queen and Companion of Science" is that younger the age, easier it is to appreciate and ~~as~~ assimilate its abstract notions. Thus the first 8, 10 or 12 years of schooling are really important. So, as far as maths. education is concerned education at the primary and secondary school level should attract far greater attention than what is being given by both educationist and mathematicians to-day.

At the level of elementary education, teaching and learning of mathematics has not deviated much from the traditional course. Even the S. M. S. G Wave (of 60's and 70's) of modernising maths. syllabi has largely left our

maths. teaching at elementary level unaffected. That is perhapse the reason why problems like, 'Why little Jhonny cannot add?' have not arisen in our country.

However, there are two main points on which I would wish to focus attention of mathematicians, scientists and educationists. It is, in general true that earlier we introduce an abstract notion to a child, the better. But then, the question remains: at what early age would a normal child be psychologically ready to understand and assimilate a new mathematical concept. Piageat has done a good deal of experimentation on mathematics-learning processes in a child and has laid down certain broad principles. But as I mentioned earlier education is a social process and we should not take up findings of experimentations on children having a radically different cultural, historical and social back-ground and apply them to our children without ever testing their applicability to our surroundings.

Let us take an example. At what stage should we introduce negative numbers, at the 3rd grade or 5th grade or 7th grade? Since we have no experimental data available regarding maths-learning abilities of a normal Indian child, our dear decisions in this regard are always ad hoc. The first burning problem of mathematics education at the elementary level is to collect experimental data and determine determine criteria to decide at which age group could we introduce certain abstract notions in Indian schools.

Incidentally I may mention that in our country we do not have Mathematics Education as a distinct desciplene in our universities. We have only reached a stage where we arrange isolated lectures by senior (or aged!) mathematicians on the subject. My plea above is essentially to have a distinct desciplene of mathematics education and there I have briefly mentioned one research problem this disciplene must take up.

An experiment carried out by the research cell of the London county school board is relevant at this stage from two points of view: (i) it deals with elementary school students speaking Indian languages and (ii) it will lead us to the second point I wish to make regarding mathematics education at the elementary level. Dr. Saifuddin, education officer at the London school board narrated this at a Unesco-sponsored conference on Language and mathematics, and I report here from memory.

With the influx of immigrants a new problem of teaching minority languages at the elementary school level came up before the board. Since immigrants are to be ultimately absorbed into the main social stream of the country it would be a wise policy to encourage the use of English by them in all circumstances and to some extent to discourage, so to say, the teaching of minority

languages. But then the question arose, 'Is such a policy educationally sound?' It was decided to conduct an experiment to see if a child's equipment in its mother-tongue is in any way related to its achievement in the most relevant school-subject: Mathematics: Children with mother tongue English, Bengali, Gujarati, Panjabi, Urdu, Greek, Italian and African language were given identical tests, one in Mathematics and another in ~~the language~~ their mother tongue. It was found that there is a strong corelation between the equipment of a child in his mother tongue and his achievement in mathematics. As a result of this test the board introduced voluntary, outside-school-hour classes in the dominant minority language of the area.

This leads us to the second point I wish to emphasize. To improve mathematics education at the elementary level it is necessary to strengthen the teaching and learning of the mother tongue which for a very large population of our students is the regional language. On the other hand during last decade or two we see a tendency among elite primary schools to discourage teaching and learning of the regional language or to begin its teaching as late as possible, say at the 3rd or 4th grade. The London experiment clearly shows that this tendency will have a very detrimental effect on mathematics education in our country.

3. Secondary Education

A point that immediately strikes one is that we,

mathematicians have hardly touched mathematics education at the primary level but have meddled a great deal at the secondary level. One reason seems to be that very large numbers involved of pupils and teachers involved at the primary level necessitate a good deal of testing and try out of material before adoption, while there is a good scope for arm-chair discussions in comfortable surroundings for mathematics education at the secondary level!

The PL-480 Rupee funds in the Sixties supplied the wherewithal for the academic pastime indulged in by University Professors (myself included), college teachers (and may be, a few school teachers) of evolving syllabii and writing text-book on 'Modern Maths'. And this process of imitating fully or in parts the ready-made material prepared in U.K. or U.S.A. came to be regarded as the begining of Maths. Education in the country. Even to-day the conventional meaning attached to the word Maths. Education implies evolving new syllabii and writing of text books.

Of course evolving syllabii is an important activity under mathematics education but the first thing to do is to lay down principles on the basis of which new syllabii are to be evolved. To illustrate the point which I want to make let me make a suggestion. I suggest that we introduce the topic of magic squares at some stage in our school mathematics syllabus. Yes, why not! We have Profit and Loss, Equations and

problems to find father's age; we have congruent triangles and areas and so why not magic squares? You may say that we did not have magic squares all these years so why have it now? What purpose it would serve? Yes, 'what purpose would it serve' represents essentially the point I wish to make. We must clearly define motives and purposes of teaching mathematics in schools.

At present the school-board or other similar bodies invite you and me as experts whenever new syllabii are to be drafted. But you and I are experts in some area of mathematics and not in mathematics education. As a matter of fact we do not have mathematicians who have specialised in Mathematics Education who can give a convincing arguement in favour of or against my suggestion above about magic squares.

The main problem of Mathematics Education at schools is to determine the proportion of the Queen-aspect and the Companion-aspect of Mathematics that we should introduce at the secondary level. And this proportion depends on the historical and cultural traditions as well as on the state of socio-economic development of our society. Clearly we mathematicians are no experts in this area. No wonder then that we go about adopting fully or in parts course-material prepared elsewhere which appeals to our mathematical sense. Along with the wave of updating school-mathematics that spread in our country in the sixties and early ~~sixt~~ seventies we should also have undertaken the development of expertise in maths. education. But better late than never. Let us now have a

full-fledged department of mathematics education in some selected centres and and develope the necessary expertise.

4. Tertiary Level

In a developing country the purpose of mathematics education at the tertiary level (i.e. at the college and the university level) differs from that in a developed country. In a developed country, there is a sort of feed-back from society to the the university. The developements in the society demand that certain branches in mathematics be cultivated and the universities take up the challange. Thus a good deal of motivation for mathematics education at this level is provided by newer and newer needs of the society. Operations Research, Mathematical Modelling, Computers Algorithms & represent demands of the society on mathematics education at the university level.

On the other hand, in a developing country like ours industrialization has not reached that sophisticated level which will require newer and newer mathematical inputs. As a matter of fact, generally it is only the school-mathematics that finds direct use and application in a developing society. Mathematics at the tertiary level is used for training scientists, engeneers and technologists who

in their turn go about constructing and manning the basic infrastructure of initial industrialized base in the country. Once the basic structure is set up and we feel the necessity of generating our own know-how, the direct use of mathematics will be needed. At present our industries and science laboratories advertise posts for technologists, engeneers, scientists, managers, marketting experts and so on, but rarely for mathematicians - A mathematics graduate or even a post doc. has to put on an additional coat of some area of management studies before he can get a job in an industry. Only when our industrialization reaches the take-off stage of generating indegenous know-how this situation will change. As a matter of fact it is only at the end of the seventh 5-year plan that recently an advertisement appeared for 14 posts of mathematicians at various CSIR laboratories!

This rather lengthy preamble clearly indicates that our present undefined policy on Mathematics Education at the tertiary level should be replace by a well defined policy with the following objectives:

(i) The mathematical equipment of scientists, engeneers, tachologists, economists, and other social scientists should be

upgraded and updated (especially at their research levels).

(2) The C. V. Raman dictum should be strictly followed. Prof. Raman pleaded for developement of pure mathematics and astronomy in order to provide a sound foundation to economic, scientific and technological progress of the country.

(3) Areas of mathematics which lead to creative (future) applications should be identified and introduced in post graduate courses.

One can make a more detailed list of objectives, but my aim in this keynote address to pin-point issues in mathematics education which have, somehow, not been given adequate attention in the conventional approach. Let me therefore end here my unconventional look at this problem.