Promoting S&T in rural India – challenges and plausible solutions

Madhav G. Deo

Lack of science and technology (S&T) education and research amenities is the root cause of rural backwardness resulting in villages being treated as 'colonies' for urban goods. Although tremendous strides have been made in S&T in post-independence India, development is mainly focused on creating big S&T institutions and upgrading S&T infrastructure in major cities ('big science', macro-S&T). Rural India, which still accounts for 70% of the nation's population, has been grossly ignored. There is an urgent need to implement the notion of 'small science' (micro-S&T) tailored for the rural sector to make villagers self-reliant. A beginning could be made by aggressively promoting outreach programmes in modern science education and research for young village students. Also, steps should be taken to establish a number of modest Rural Institute of Science Education and Research (sort of mini-IISER) spread all over the country with the ultimate goal of 'science for all'. In the present setting, competition between rural and urban youth is uneven and unjust. It is time we provide villagers a level playing field and take them on board as equal partners. This is the only way to prevent emergence of two sub-nations 'Bharat' and 'India'.

Keywords: Outreach programmes, RISER, rural India, S&T.

Looking at the changing economic scenario, it is estimated that the contribution of agriculture to the overall gross domestic product (GDP) will dip from the current level of 20% to 10% by 2020 in India[1]. In consequence, some 70 million rural people (more than the population of France) will migrate from ecofriendly villages to highly polluted city slums in search of jobs. The best way to prevent migration will be to provide urban amenities and opportunities to rural folks. Certainly, the urban consumer amenities are now increasingly making inroads into rural India. A large number of village homes now have direct-to-home (DTH) televisions. Number of power driven two wheelers is increasing everyday in rural India. These are just a few examples. But availability of consumer goods is no solution, as villages are simply used as colonies for urban goods. Villages must come out of these colonies and this can only happen if they become producers rather than importers of goods and knowledge. The best solution lies in promoting in a big way modern science and technology (S&T) and information technology (IT) education in the rural sector so that villages participate in national industrial growth.

After independence, many national institutes established extension centres and their scientists and technologists provided solutions to village problems in spare time[2]. Most of these models failed as no attempt was made to equip villagers to solve problems by themselves and become self-reliant. In our mindset, 'farmers', a tag every villager carries, are considered to be incapable of absorbing modern S&T. Rural India therefore continues to be poor because its economy is based on labour-intensive agriculture and agro-based industries requiring low skills. On the basis of programmes run by the Moving Academy of Medicine and Biomedicine, that are described here, it is evident that rural students are intellectually as good as their urban counterparts. They are also highly motivated to gain new knowledge and in that respect they are better than urban youth.

Madhav G. Deo is in the Moving Academy of Medicine and Biomedicine, 13, Swastishree Society, Ganesh Nagar, Pune 411 052, India.
e-mail: deo.madhav@gmail.com

S&T in independent India

There has been phenomenal rise in the total R&D expenditure in India since independence. Allocation for S&T in the second five-year plan was just Rs 70 crores. In the current (11th) plan, it has been raised to Rs 75,000 crores, a little more than 1000-fold increase. The number of S&T research institutions and centres of excellence have also increased tremendously and efforts are being made to provide the latest gadgets to our scientists. However, more than 80% of these institutions are located in major cities with population of more than one million. Indian science as a whole has done well with a number of globally recognized laudable programmes; the one, which stands out is *Chandrayaan I*.

We must strongly support these programmes and Indian scientists must get access to the latest gadgets and technology to make S&T globally competitive. But this is no justification to totally ignore villages, although at almost all forums lip sympathies are given to the poor state of S&T in the rural sector. Thus what we are witnessing in India is the growth of 'big science'. We call this growth pattern as 'mega (macro)-S&T' which is a somewhat lop-sided development focused on cities. Needs of the rural sector may be better addressed through creation of a large number of small modestly equipped regional education and research institutes. This is 'small science' or 'micro-S&T'. The notion of two distinct programmes of different magnitude – macro and micro – has been highly successful in the finance sector. It is not a big dam but local water conservation programmes that is providing a solution to the water shortage problem in rural India. Growth of S&T would be more balanced if similar approaches were adopted.

Spotting young talent

A vast majority of students in all societies are mainly interested in finishing education within the prescribed syllabus and getting settled in routine jobs. School and college teaching in India is therefore mainly geared to complete the syllabus. Further, fast-expanding frontiers of knowledge have put an additional strain on our educational system. Hardly any attempt is made to tune curricula, which are static, to the fast expanding knowledge frontiers. This has resulted in a progressively increasing gulf between 'what is known and what is taught'. The gulf must be bridged to make our education globally competitive.

Today school educational system has degraded to such a level that rote learning and cramming are considered key to success. Unfortunately, this is also the perception of the teaching community as well as a large proportion of parents. 'Coaching class' culture, which is often patronized by teachers, has further added to the woes of students killing all self-learning initiatives. In consequence, teaching is stereotyped, boring and non-exciting especially for bright students who are keen to acquire new knowledge beyond the syllabus. Although their numbers may be small (around 5%), it will not be out of place to say, that progress in S&T depends ultimately on this small bright 'knowledge hungry' student population. These problems affect both the rural and urban students. But the latter can take the help of city-based institutions of higher learning and research. Special programmes are needed for the bright rural students.

Einstein said 'Imagination is more important than knowledge' putting creativity above scholarship. Irrespective of caste, creed, race, geographic location and socio-economic status, creativity is evenly distributed. On that count, rural India would account for 70% of our talent that has remained untapped for want of opportunities. These gifted children have a different mindset and cannot be spotted through conventional examination-based programmes such as National Talent Search, which predominantly test scholastic abilities. Providing opportunities for research at a young age are perhaps the best approach to spot creative minds in science.

Educational programmes for talented students in rural India

The Moving Academy of Medicine and Biomedicine, which was established 8 years ago, has developed two novel, cost-effective and highly successful programmes to meet these challenges. The aim of the first programme 'Discovering little scientists' is to provide research opportunities to talented students at a very young age. The second programme aims at exposing these students to knowledge beyond their books through 'mobile science fairs'.

Discovering little scientists

The programme targets 15–18 years old secondary school and junior college students predominantly in the rural sector. Its objective is to provide students with research aptitude opportunities to work on modest research projects. This two-month programme with a strong hands-on component was conducted for the first time in the summer vacation of 2009. The programme was announced through newspapers and my personal contact with colleges in Pune and the adjoining rural sector. In addition to providing his/her brief CV, each applicant had to write a two-page essay on any one of the following six topics, viz. diabetes, heart attack, cancer, stem cells, gene cloning and genetics. The candidates were interviewed and selected on the basis of their performance. Due credit was given to the applicant's essay. Participation was entirely voluntary. A total of 10 'little scientists', who had just appeared for the SSC examination of the Maharashtra State Board of Secondary and Higher Secondary Education, were selected (1 from Pune, 3 from small towns and 6 from villages in Pune district). They were divided into five groups, each having two students.

All the 'little scientists' worked on a common project titled 'Screening for Chronic Kidney Disease' (CKD). The aim of the project was to screen adults (18 years and above) of both sexes for CKD using simple field-based non-invasive procedures (only urine examination) in urban and rural India with focus on detection of early silent forms when treatment could improve the outcome. Five centres were established (Figure 1); two in Pune and one each in three rural sectors – Parinche and Kaldari (both in Sasvad taluka, Pune) and Asade (Mulsi taluka, Pune). The two Pune centres were Girjashankar Vihar in Karve Nagar (middle class locality) and Bhau Padal Vasti in Khadki (low-income group).

Before starting the project, 'little scientists' were given one-week orientation course during which they were imparted training in recording information in the clinical proforma designed for the project, measure height, weight and blood pressure under field conditions, handling of common laboratory instruments and routine urine examination, and to conduct some special tests (estimation of urinary proteins and creatinine).

Four days in a week were devoted to field (home visits) and lab work consisting of routine examination of urine for which a field laboratory was set up at each centre. The rest of the two days were spent in the Academy's Pune training centre on 'academics' which consisted of:

- Seminars by 'little scientists'. The 10 topics chosen for this purpose were cell structure and function, DNA structure and function, gene cloning, genetics, HIV, digestive system, white blood cells, red blood cells, 'Dolly' and stem cells. Each student was allotted one topic.
- Lectures were held on 'Elementary statistics and data management', 'How to design a research project?' and 'How to write a report/paper?' Most of the students had hardly any exposure to computers. They were given lessons in use of computers and computer software especially Microsoft Office. Later they used Microsoft Excel to record and analyse their data.
- Lecture-cum-demonstrations were held on commonly used techniques such as polymerase chain reaction (PCR), gel electrophoresis, enzyme linked immunosorbent assay (ELISA), spectrophotometer and tissue culture.

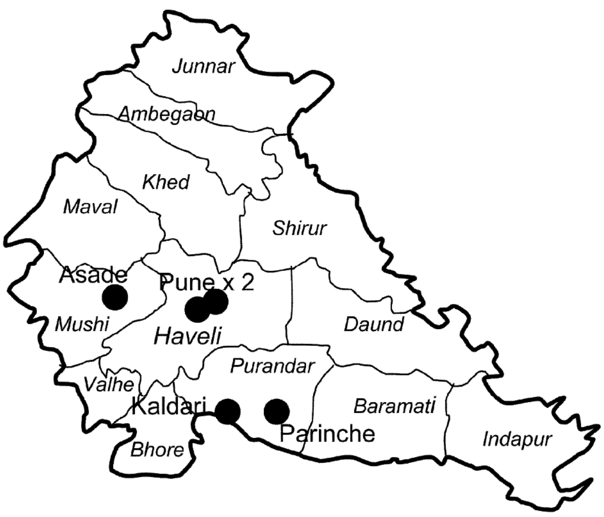

Figure 1. Pune district map showing the five study centres (•). Thin line denotes the borders of various tehsils.

- Special lectures on topics such as 'Life on other planets', 'Gene transfer techniques', and 'Plant breeding' by internationally well-known scientists.
- Visits to leading laboratories such as National Centre for Cell Science (NCCS), and Indian Institute of Science Education and Research (IISER) in Pune.

A total of 781 (little more than 150 participants in each centre), both males (33%) and females (67%) above 18 years of age, participated in the study from the five centres. Briefly one third of the urban dwellers were overweight (BMI > 25) that was still not a major problem in rural sector. In fact about 14.3% of villagers were grossly underweight (BMI < 16.5). Hypertension in the rural sector was seen in only a small proportion (10%) of people, which was nearly one-third of the values observed in the Pune communities. Almost 20% of hypertensives (both in cities and the rural sector) were not even aware that they were suffering from the disease. Hypertension showed overall correlation with increasing age as well as BMI. Prevalence of CKD as measured by the presence of microproteinurea varied from 6% to 20% in different communities. The results of prevalence of both CKD and hypertension were similar to that observed in the national multi-centre Screening and Early Evaluation of Kidney Disease (SEEK) study[4]. The 'little scientists' prepared posters using Microsoft Power Point, which were exhibited at the valedictory function that was held in the Pune IISER complex.

It should be emphasized that this is a pilot study. The sample size in each centre is too small to draw any definitive epidemiological conclusions. The study has, however, eminently met the objective of creating a research module that combines community and laboratory-based research for little scientists. The novel approach will promote scientific temper at the grass root and revolutionize science education in rural sector. The programme was highly appreciated and received an average rating of 9.6 on the scale of 10 in the participants' feedback. In view of my background, the project was launched around a medical and health-related topic. But the spectrum should be expanded and include topics in all science disciplines both in biological and physical sciences. It should also be made multicentric.

Mobile science fairs

As mentioned earlier, the fast expanding frontiers of knowledge have resulted in creating a gap between what is known and what is taught. To bridge this gap, the Academy has developed, for medical colleges, a highly successful cost-effective novel approach of mobile workshops that takes new knowledge to students' doorsteps[5]. It was felt that a modified version of this programme could be used to expose young talented students in the rural sector to excitement in S&T.

During implementation of the programme 'Discovering Little Scientists' I frequently travelled to Parinche and nearby villages in Purandar taluka of Pune district. A perusal of the locations of SSC schools shows that there are some 8 schools in close vicinity of Pariche (Figure 2). This is an ideal situation to develop common outreach educational programmes for 'knowledge hungry' students in this area.

I personally went to each school and with the approval of the school authorities addressed the class X (SSC) students giving them details of the programme. It was emphasized that the participation in the programme would give them no advantage for their SSC Board Examination and that participation was completely voluntary. The total number of class X students in these schools was 325. It was thought that at best some 20–25 students would register, but to our pleasant surprise 86 students (30% of the student population) participated in the programme, an indication of keenness of rural students to participate in such extracurricular teaching activities.

A pilot project consisting of two workshops has been completed. The workshops, which had a strong hands-on component, were conducted once a month on a Saturday. The necessary laboratory equipment was transported from the Academy's training facility in Pune. The first workshop was held on 'General lab procedures and lab equipment', in which the students were acquainted with commonly used laboratory equipment and their functioning such as photometer, gel electrophoresis, centrifuge, a research microscope, types of pipettes, pipette-aids, etc. The concepts of molar and normal solutions, buffers, and the basic principle of Beer–Lambert law were discussed. Every participant was provided opportunities to use the equipment around some laboratory exercises. For example, to test Beer–Lambert law they were given a series of protein standards estimated by Biuret reaction and also an

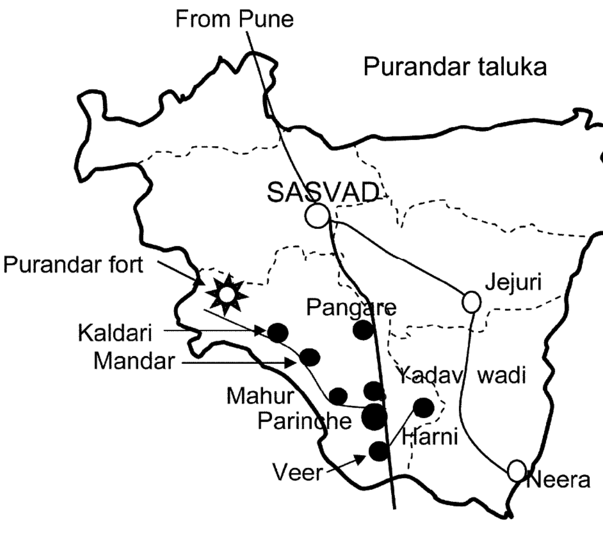

Figure 2. Locations (•) of SSC (X standard) schools in the vicinity of Parinche.

unknown solution. They were then asked to construct a standard graph of optical density versus protein concentration that was later used to estimate the protein level in the unknown solution. The second topic was blood and its components, in which the different cellular components of blood, red blood cells (RBC), platelets and white blood cells (WBC) were described. Methods of quantitation of these components were demonstrated. The participants were shown structure of RBCs, platelets and five different types of WBCs namely neutrophils, eosinophils, basophils, lymphocytes and monocytes, under a microscope. Every participant prepared a blood smear which was stained using Giemsa. The stained slides were examined by them under the microscope. The students were given a basic idea of structure and function of haemoglobin (Hb). The participants also estimated blood Hb concentration using Drabkin's reagent[6] and were shown cellulose–acetate electrophoresis separating Hb into HbA and HbA2. Each participant was given the opportunity to perform blood grouping both ABO and Rh system using standard kits. At the end of the session they were given a live demonstration in the use of sophisticated automatic blood cell counter.

Before starting the programme, the students were asked as to how much they knew about these topics. They had some idea about blood groups as it was a part of their syllabus. However, they had very little information on other topics. No pre-workshop multiple choice question (MCQ) test covering the workshop topics was therefore conducted. However, to get an idea of their general science level a broad based MCQ test, which was based on the topics covered in the SSC syllabus, was administered. A post-workshop test based on the workshop topics was also conducted. In the pre-workshop test, the average score was 34.4% and only 3 students scored >50% marks. On the other hand, in the post-workshop test the average score was 63% (Figure 3). Only one student failed (<50%). Ten per cent of students scored 80% marks (Figure 3). The result of the post-workshop tests is a clear indication of capabilities of village students to grasp highly complex new topics. The programme has now been extended to the next two months during which workshops will be held on 'elements of protein and nucleic acids biotechnology'.

S&T educational and research in rural sector

Lack of educational opportunities is the root cause of rural backwardness. In rural Maharashtra there are a fair number of SSC schools, which often show clustering around a modest town that has reasonable infrastructure, as is the case with Parinche. These schools offer teaching up to standard X, but for higher science education, students have to travel to far off Sasvad (taluka headquarter), with the result science students have to often give up

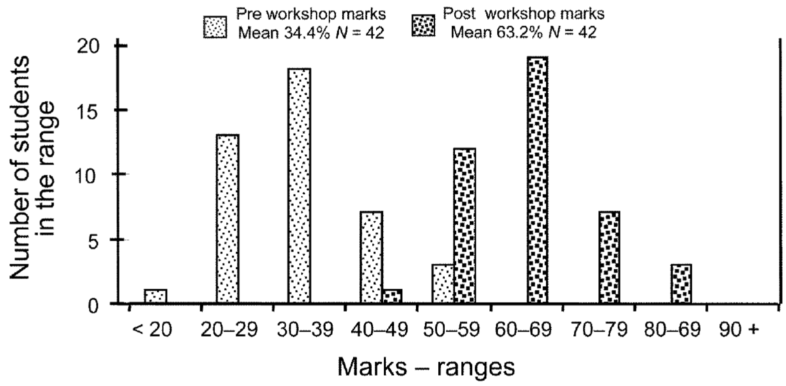

Figure 3. Pre- and post-workshop multiple choice question tests.

studies, which grossly affects their job opportunities. There is a vast difference in the opportunities available after passing SSC (standard X) and HSC (standard XII). After completing HSC (Junior College), a science student would qualify for admission to almost all professional courses (medicine, engineering, dentistry, etc) or can also take science stream (B Sc, M Sc, etc.). Just SSC pass students, on the other hand, can at best get only lowly paid jobs such as technicians, electricians, plumbers, etc. Availability of laboratory infrastructure could induce local SSC schools to start junior science colleges that would completely transform the fate of the young rural students bringing them into the main science stream. It is not essential that each school must have its science laboratory. Taking advantage of the clustering of schools, a common regional science laboratory facility, which would take care of the entire science education both theory and practical for XI and XII standard students, could be established at a convenient central place. Depending on the number of students, each school would be allotted a specific day and time every week to make use of the facilities. Suitable fee could be charged from the students to make the facility self-sustaining.

In 1994 with the aim to universalize primary education in India, which is now the right of every child, the District Primary Education Programme (DPEP)[7,8] was launched with the central and state governments contributing 85% and 15% respectively towards the budget. A similar District Higher Secondary Education Programme should be launched as early as possible to promote higher secondary education in rural India. To facilitate implementation of the programme, there is a need to establish a number of modestly equipped autonomous Rural Institutes of Science Education and Research (RISER). Each RISER, which is a sort of mini-IISER, will carry out all the three functions – education, research and service. The educational component essentially will include providing infrastructure for S&T education at SSC and HSC levels and conduct outreach mobile science education programmes in the region. There should be special emphasis on 'knowledge update' programmes for SSC and HSC teachers. Each RISER should develop talent search programmes such as 'Discovering little scientists' in collaboration with other advanced institutes. DST has recently launched a talent promotion programme 'INSPIRE', which in the present form is chiefly city centric. The rural institutes could make the programme a truly national initiative by implementing it in the rural sector. Service component would consist of undertaking testing for quality of water and milk, food adulteration, etc. and providing scientific solutions to problems of 'farmers'.

Future

Dr Manmohan Singh, Prime Minister of India, launched the first National Institute of Science Education and Research in Bhubaneswar in August 2006 (ref. 9). Subsequently, a number IISERs have been established in different parts of India and their number is increasing every year. Each one gets an initial establishment grant of Rs 500 crores, and annual maintenance budget of Rs 20 crores. We must welcome this initiative, which is aimed at improving the quality of science education. IISERs are all city-based institutions. Their selection procedures are heavily biased in favour of just those 5–7% of students who are well versed in English. Even a bright student from the rural sector has hardly any chance of entering IISERs because of poor knowledge of English. The solution lies in providing quality higher secondary education to rural students so that they can compete with their urban counterparts. It is only then that IISERs will become truly national institutes.

Each RISER would need a modest establishment grant of Rs 4–5 crores, and a maintenance grant of Rs 75 lakhs, which is even less than the annual scholarship budget of one IISER. In other words some 75 RISERs could be created in the budget earmarked for one IISER. In short, the suggestion is to create a number of such rural-based institutes spread all over rural India. The ultimate aim should be 'science for all' by creating such institutes within 10 km radius of each village so that no deserving village student ('little scientist') is denied research amenities and higher science education that would open for him a sea of opportunities. The rural institutes should have close links with IISER in the region. This will ensure quality education to students in the rural sector.

In view of our robust and fast growing economy (India is expected to be the fifth largest economy by 2020) finances are unlikely to be a major problem. The main hurdles will be lack of political will and our mindset, which needs to be changed. It is high time, we accept that given the opportunity 'farmers' could also be S&T leaders. A beginning could be made by expanding quality higher secondary educational facilities, through establishment of a number of rural based modestly equipped S&T institutes (RISER), simultaneously implementing cost-effective fast track programmes of 'mobile science fairs' and 'discovering little scientists' for nurturing bright creative minds in rural India.

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