Nurturing science talent in villages

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Creativity or out-of-the-box thinking is evenly distributed in all societies in the world. On that count rural India should be a major source of creative minds that has remained untapped. Due to our city-centric policies, it may take decades before modern science and technology (S&T) reaches rural India. Meanwhile the Moving Academy of Medicine and Biomedicine, Pune has developed a module to nurture talent in the villages. The module essentially consists of a base laboratory and village-level hub of modern S&T with extensive innovative outreach programmes for village schools. The programmes carry no reward, are open to all but totally voluntary and are held during holidays, on current topics outside the student's curricula. For these reasons the programmes attract only committed talented students. The module has the potential to change the face of S&T in rural India, expanding the national pool of creative minds, which is the need of the hour.

Keywords: Creative minds, outreach programmes, rural areas, science talent.

TREMENDOUS strides have been made both in scientific research and education in India since independence. The budget allocation for science and technology (S&T) in the current plan is about Rs 75,000 crores, which is about 1000 fold the allocation in the second Five Year Plan (1956)[1]. Indian science as a whole has done well with a number of globally recognized laudable programmes such as *Chandrayaan I*. There is enormous expansion and improvement in the research and development (R&D) sector; the number of institutions has gone up tremendously and infrastructure in many institutions is now of global standard. The number of universities has increased from 20 to 431 (21 fold) and college enrolment from 0.1 million to 11 million (110 times) between 1950 and 2008 (ref. 2). However, the quality of education has been a major victim of this rapid and enormous expansion, as reflected by the country's dismal publication record[3]. India today stands at number 10, whereas China has surged ahead and is only second to USA in the number of publications[3]. No Indian university figures amongst the top 50 universities of the world[4]. Poor quality of education has adversely affected innovations, which is one of the weakest areas of Indian S&T. In 2007–08, only 35,000 patents were filed from India. In the same period China filed more than 2 million patents[5].

The rate of innovations is directly proportional to the pool of scientists which is low. India currently has about 120,000 scientists, which is just one-tenth of the number in USA[2]. A major challenge is how to increase this pool in the face of declining interest (enrolment) in science education[6] and high dropout rate. Another factor is that most developments, both in R&D and science education, have been city-centric; the rural sector has been grossly ignored. Our cities have a fairly good density of educational institutions. For example, in Pune, the total number of secondary schools and junior colleges is 340 and 70 respectively, and 94% of those who have cleared the Secondary School Certificate (SSC) examination have a reasonable chance of getting admission to the subject of their choice[7]. The scenario for higher science and technical education in cities is not bad. In fact for the last few years, thousands of seats have remained vacant in engineering colleges[8]. A similar trend is now seen in dental schools, although at a much smaller scale[9]. It thus appears that cities now have reasonable science amenities. Marginal increase might still be achieved by further increasing S&T amenities in cities, but we must look for alternative options to increase the science pool.

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. There should therefore be no difference in the density of 'creative' (talented) students in cities and villages. It is difficult to quantify creative (gifted) children. However, a good assumption is that creativity shows normal distribution. In this pattern majority of the students (68.2%) will be in the 'average', 13.6% in the 'good' (above average), 2.1% in the 'bright' and 0.1% in 'very bright' categories. This is also supported by the results of an IQ test on a large enough population in which the distribution has the shape of a Gaussian function[10]. It may not be out of place to mention that progress in S&T depends ultimately on this small number (3–5%) of knowledge-hungry, 'gifted' students. They have a different mindset and cannot be spotted exclusively through prevailing conventional

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examination-based systems, which predominantly test scholastic abilities.

With a view to nurture talented students, the Government of India has launched several programmes. Some of the prominent ones are: (i) National Talent Search[11], (ii) Jawahar Navodaya Vidyalayas[12], (iii) Kishore Vaigyanik Protsahan Yojana (KVPY)[13], (iv) Innovation in Science Pursuit for Inspired Research (INSPIRE)[14] and (v) Establishment of Indian Institutes of Science Education and Research (IISERs)[15]. However, except Jawahar Navodaya Vidyalayas, all others are city-centric and heavily biased towards those well versed in English, which accounts for only 5% of the student population. Although a student may get the option to write examination papers in regional languages, the level of science education in local languages is poor. In the process all the National Talent Search schemes do not benefit 95% of our youth. Students from rural areas, who have little exposure to English, are the worst affected. Almost all programmes test only scholastic abilities. There is hardly any emphasis to test 'creativity'. A major challenge is how to spot talent locally in the village setting so that economically poor students can be nurtured without being displaced from their milieu.

Creativity being evenly distributed, our 'creative pool' can be tripled by tapping the intellectual capital that resides in hitherto highly neglected villages which account for 70% of India's population. Under the prevailing conditions to provide modern S&T amenities in village schools is a Herculean task that may take decades. However, a beginning could be made by supplementing school education with thought-provoking outreach programmes on topics outside the students' syllabus. Further, programmes should be voluntary, open to all and held either during vacations or on holidays/Sundays, so that only knowledge-hungry, talented students are attracted.

Outreach programmes for nurturing talent

The Moving Academy of Medicine and Biomedicine has developed two such novel programmes, namely (i) Discovering little scientists and (ii) Mobile science fairs, which has established feasibility of this approach.

Discovering little scientists

The aim of this programme, which was conducted for the first time two years ago during summer vacation (between April and June), was to provide research opportunities to students at a very young age (15–18 years). The programme is widely publicized in local newspapers. Special efforts are made to contact school students in the nearby rural sectors. In addition to providing his/her brief CV, each applicant has to write a short, two-page essay on some current topics. Last year the essay topics were on diabetes, heart attack, cancer, stem cells, gene cloning and genetics. Selection is made on the basis of the performance of the candidate at the interview. Due credit is also given to an applicant's essay.

Participants are divided into suitable groups and allotted research projects. Because of the medical background of one of the authors, the students work mostly on community-based, health-related topics. The five research topics (four clinical and one basic) that were given to the students last year were: (i) community based screening for chronic kidney disease (CKD), (ii) prevalence of hypertension, (iii) recording body mass index (BMI) in villagers and in urban slum-dwellers and (iv) prevalence of anaemia in urban slums. One group was given the basic project of testing anti-cancer activity in some Ayurvedic preparations using animal tissue culture systems.

Each little scientist is given one week orientation course in methodologies relevant to his/her research topic. For example, those working on community health-related topics are imparted training to: (i) record information in the clinical proforma designed for the project, (ii) measure height, weight and blood pressure under field conditions, (iii) handle common laboratory instruments, (iv) measure Hb levels and perform routine urine examination under field conditions and (v) conduct special tests (Hb electrophoresis, estimation of urinary proteins and creatinine), which are conducted in the Pune laboratory of the Academy. Students working on *in vitro* project are imparted special training in animal tissue culture.

A typical week's programme consists of:

(i) Four days of field (home) visits and conducting simple laboratory tests such as routine examination of urine and Hb estimation for which village-level field laboratories are set up.
(ii) The remaining two days are spent in Pune training centre of the Academy on performing specialized tests, students' seminars and other academic activities. The latter consist of seminars by 'little scientists' on current topics. Some of the topics on which students' seminars were held last year include stem cells, HIV, GM crops, cancer, diabetes, cell structure and function, genes, gene cloning, blood and blood cells, digestive system and blood circulation. Scientists from the Academy give lectures on research methodologies, science writing and use of computers. Lecture-cum-demonstrations are also held on commonly used laboratory techniques such as PCR, gel electrophoresis, ELISA, spectrophotometer and animal tissue culture. Special lectures are delivered by globally well known senior scientists. Also, visits are arranged to leading laboratories. In the last two years the students have visited the National Centre for Cell Sciences, Pune; Indian Institute of Science Education and Research, Pune, and Advance Cancer Treatment, Research and Education Centre, Navi Mumbai.

Two year ago when the programme was launched 100 applications were received from all over Maharashtra. Out of this ten 'little scientists', who had just appeared for the SSC examination of the Maharashtra State Board of Secondary and Higher Secondary Education, were selected (one from Pune, three from small towns and six from villages in Pune District). Last year 21 (double the number of the previous year) 'little scientists', were selected, four were from Pune, nine from small taluka towns and eight from villages. There were 16 girls and 5 boys.

At the end of the project, collected data are analysed and results presented as posters prepared by the students under the guidance of the staff of the Academy. The posters are exhibited at the valedictory function. Only highlights of the data obtained by last year's 'little scientists' are discussed below.

(1) The studies on CKD, hypertension and BMI were conducted at six centres: one in Pune (low income community), one in semi-urban Khed and four in rural Maharashtra.

(2) Projects were cleared by the institutional ethics committee and due informed consent of the participants was obtained.

(3) It should be emphasized that this is a pilot study. The sample size in each centre is too small to draw definitive epidemiological conclusions.

(4) The main objective of this project was to establish the feasibility of the concept that useful, community-based research can be conducted at a very young age.

(5) Results based on pooled samples of all the six centres are as follows:

(i) A total of 917 people (both males and females) participated in the different centres.
(ii) The projects were focused on adults and adolescent, school-going students. The age groups were similar in all centres.
(iii) Whereas nearly one-third of the urban and semi-urban adult population was overweight (BMI > 25), this was still not a major problem in the rural sector. On the other hand, about 23.05% of adult villagers were grossly under weight (BMI < 16.5); an indication of under nutrition.
(iv) Hypertension in the rural and semi-urban sectors was seen in 12–16% of people, which is nearly one-third of that observed in the Pune upper middle class community.
(v) Almost 20% of the people suffering from hypertension (both in the cities and the rural sector) were not even aware that they were suffering from the disease.
(vi) Hypertension showed overall correlation with increasing age and BMI.
(vii) Prevalence of CKD as measured by the presence of proteins varied from 6% to 20% in different communities, a fluctuation similar to that observed in the multi-centre study of Screening and Early Evaluation of Kidney Diseases (Acharya Vidya SEEK report 2008, pers. commun.).
(viii) Regarding anaemia, it was a significant problem in Pune slum-dwellers, being present in 28 out of 88 (32%) adult females.

Mobile science fair

During implementation of 'Discovering little scientists', the authors frequently travelled to Parinche (about 50 km southwest of Pune) and nearby villages in Purandar taluka of Pune District and observed a sort of clustering of village schools, which was an ideal situation to develop outreach educational programmes consisting of mobile workshops for talented students in the region.

Before starting the programme, the authors personally went to each school in the region and addressed class X (SSC) students, giving them details about the programme. Special emphasis was given to four points:

(i) Workshops would be on current topics which were outside the students' syllabus.
(ii) Participants would get no advantage for their SSC Board Examination.
(iii) Participation was open to all, but totally voluntary.
(iv) The programme did not carry any reward.

Further, since the workshops are held on Sundays and holidays, they would attract only highly committed students.

It was thought that because of these stipulations at best 10–20 students would volunteer for the programme. But to our pleasant surprise about 30% students (82/283) participated in the programme when it was launched two years ago. Last year more than 100 students attended the programme. To make it highly interactive, the students were divided into two groups of 50 each, which was further sub-divided into four nearly equal subgroups. Each workshop consisted of four different sets of experiments and each subgroup was rotated. The workshop on the same topic was repeated on two different Sundays. There were hardly any dropouts.

The programme essentially consists of conducting workshops with some hands-on component on current topics in life sciences. Workshops are held once a month on a Sunday between August and December. The necessary equipment is transported from the training facility of the Academy in Pune. Power supply in villages is erratic and sometimes power shutdown lasts for 10–12 h. Two battery-operated UPS units (810 kV each) were also taken from the Pune laboratory. They provide adequate power to run workshops for 6 h, as most of the equipment is battery-operated. Workshops have been held on four topics, namely (i) general laboratory procedures and commonly used equipment, (ii) blood cells and blood group, (iii) elements of protein biotechnology and (iv) genes and nucleic acids. The spectrum of the workshop topics would be expanded in subsequent years. For maximal impact instructions are given in local language; in the present case, Marathi.

Before starting the programme the students were asked how much they knew about these topics. They had hardly any idea about the workshop topics. No pre-workshop test was administered. A post-workshop MCQ test, conducted on protein biotechnology, was administered to 37 students in Parinche. The average score $\pm$ SD was 64.9% $\pm$ 12.45. Ten students (27%) scored more than 75% marks. Only four students had marks between 35% and 45%.

The students' performance in these programmes clearly shows the enthusiasm and absorption power of students in the rural sector to acquire knowledge of modern S&T, simultaneously establishing the feasibility of the outreach programme as a means of promoting modern S&T in the rural sector. In students' feedback, both the programmes got average rating of 9 in the scale of 10, an indication of their huge success.

Learning through experimentation

Both the above-mentioned programmes, which are restricted to students of classes X–XII, are not suitable for lower classes. Nurturing of talent should ideally start in the lower classes. Further, to promote scientific temper, it is necessary to conduct the programmes in village schools. With this in view the Academy has recently launched the programme of 'Learning through experimentation', which is conducted in village schools for class VII–IX students.

Didactic teaching is the most widely practised teaching modality all over the world. However, to spot imaginative and analytical brains, the best approach will be to use the system of experiential learning or 'learning through experimentation', where observations are made first and reasoned out later. This form of teaching requires that the learner should be actively involved in experiments and should have an analytical mind to interpret the results and conceptualize the observations.

A simple experiment could be on electromagnetism. Every child plays with a magnet. The materials for the experiment would essentially consist of a nail, a piece of insulated wire, a dry battery and iron filing. None of the items by itself is a magnet. But a nail wrapped in insulated wire when connected to a battery would function as an electromagnet. Magnetism is lost on breaking the current. The participants are now asked to reason out the phenomenon, using the internet if necessary. At the next session the students are shown an electrical bell that is based on the same principle. This is just an example. Similar experiments could be planned for other science disciplines – chemistry and life sciences.

Regional hub for S&T (RHST)

It is not easy to carryout all the three programmes entirely from city-based laboratory. One approach will be to create a network of modest, modern S&T and R&D regional hubs (centres) in suitable rural setting with huge outreach programmes so as to cover every village school and provide every talented student access to these amenities in the region. Every centre will also provide R&D support for local issues such as testing quality of milk and drinking water. These regional hubs in the rural sector would have close interaction with a base laboratory. The concept thus envisages two levels of organization consisting of a base laboratory connected with a number of field hubs, which in turn network with schools in the region (Figure 1). Their functions are briefly described below.

The base laboratory will carry out the following functions:

(i) Summer research programme ('Discovering little scientists') for class X–XII students.
(ii) Hands-on workshops for teachers of secondary schools and junior colleges.
(iii) 'Mobile science fairs', hands-on workshops to supplement the existing courses, especially in emerging areas for talented SSC and HSC students.
(iv) Provide operational and technical support for the programmes of the field laboratories.
(v) Interact with national laboratories on specific programmes, especially requiring highly sophisticated S&T.

Field-based RHST is really the heart of the programme. It will conduct the following functions:

(i) Weekend research programmes for talented students with research aptitude.
(ii) Hands-on workshops for primary and secondary school teachers.
(iii) Periodic 'Mobile science fairs' using the system of 'Learning through experimentation' for class VII–IX students, supplementing the existing science teaching. These workshops will be held in village schools.
(iv) Conduct, with the help of the base laboratory, short-term hands-on workshops on modern technologies relevant to life sciences industries (hybridoma, genetic engineering, plant tissue culture, etc.)

located in rural sector. This will be a big boon for school 'dropouts' who had to give up studies because of financial constraints. The training would improve their job opportunities in the expanding biotechnology industries.

(v) Provide services requiring modest technologies such as testing the quality of milk and water, analysis of soil, etc.

Resources mobilization for RHST

Establishment of a RHST requires finances and human resources. The latter would be best met by promoting participation of school teachers in the region. It is our experience that every school has a few committed teachers who, given the opportunity and training, could form the backbone of the programme.

The first National Institute of Science Education and Research was launched by the Prime Minister of India[16] in August 2006. Later, a number of similar institutions, i.e. IISERs, were established in different parts of India and their number is increasing every year. Each IISER gets an initial establishment grant of Rs 500 crores and an annual maintenance budget of Rs 20 crores. Each RHST will need roughly Rs 5 crores as establishment cost and Rs 1 crore as annual maintenance grant. In other words, some 100 such modest hubs could be created in the amount spent in the establishment of one IISER. Eliminating towns, which are more than 5000, creation of some 1500 RHSTs will bring modern S&T and R&D amenities within a radius of 25 km of each village, and with even modest road connectivity every village school could be easily approached through outreach programmes making science available to every talented villager. This is the notion of 'science for all'.

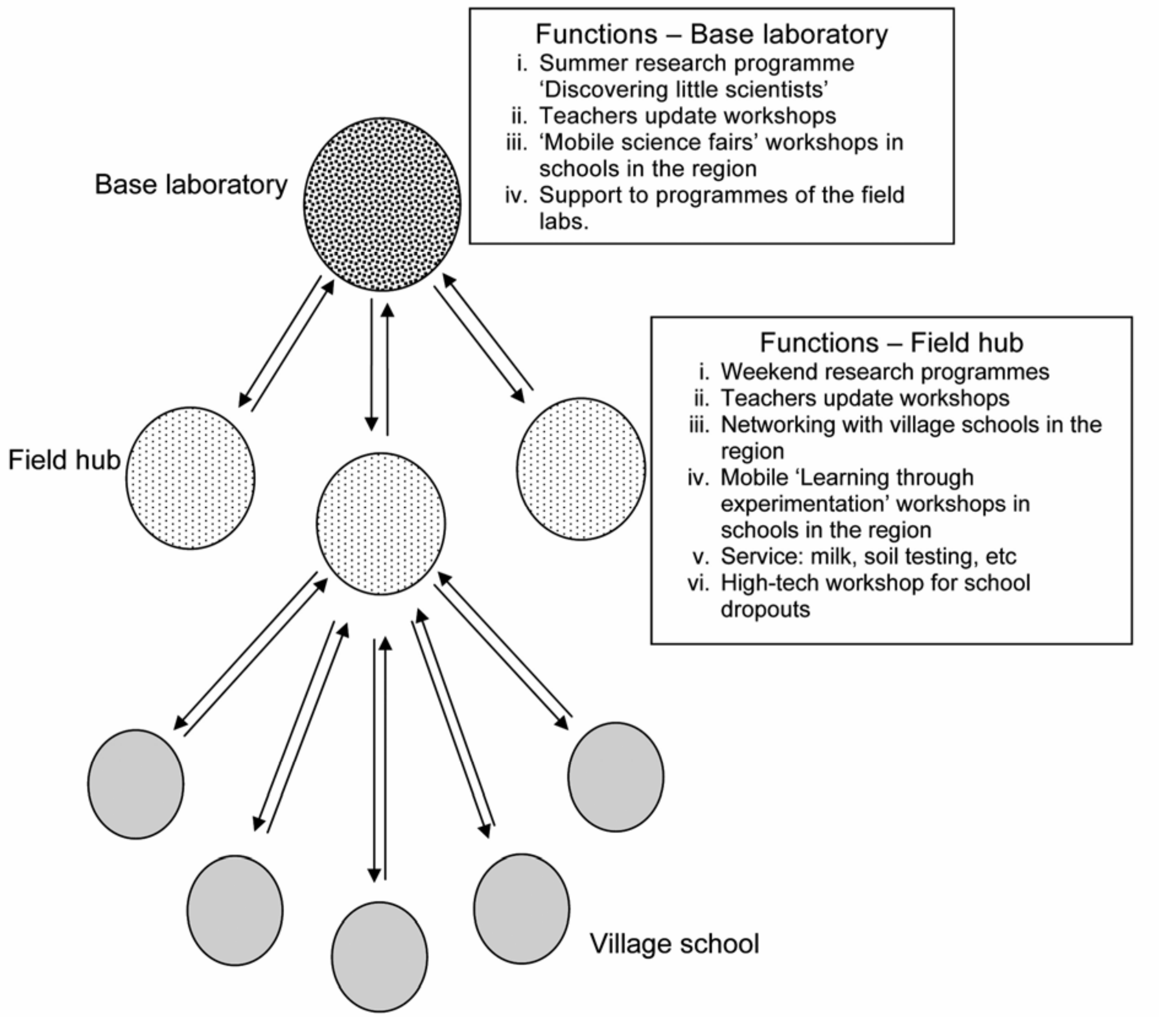

Figure 1. A module for a rural hub for science and technology.

Thus resources will not be a major problem in implementing this concept which, if successful, has the potential of taking modern S&T to every village school and developing a system to identify talent at a very young age. Suitable mechanisms could be found to support financially the talented youth identified through these programmes thus bringing them into the main-stream and in the process expanding our science 'creative' pool, which is the need of the hour.

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