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*National Conference*  
*on*  
***SCIENCE EDUCATION - CHALLENGES OF QUALITY***

*12, 13 Sept., 2007*

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Editor  
A. P. Deshpande



NATIONAL CENTRE FOR SCIENCE COMMUNICATORS

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HOMI BHABHA CENTRE FOR SCIENCE EDUCATION

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## PREFACE

The National Centre for Science Communicators (NCSC) was set up 13 years back to develop science communication in India. It is a pulsating science communicating organization with national and international reach. Its members include science communicators from varied fields of communication – print and electronic media, museums, Planetaria and so on. The Centre provides opportunities for science communicators to explore and express their talents and creativity for better understanding of science and recognize such talents. Presently the membership strength is 169 spread across the country.

One of the most dynamic campaigns of NCSC is its intensive interaction with teaching community to inculcate excitement regarding science education and scientific method of knowledge transfer. In the year 2009 NCSC organized lectures, debates and training courses for college and school teachers and students to celebrate the bi-centenary of Darwin. NCSC has been conducting science journalism courses both in Marathi and English.

NCSC has published a National Directory of science communicators and a National Directory of science propagating organizations, GO's and NGO's for easy access to information regarding science communication.

The Centre organized two international conferences for science communicators, one at IUCAA, in Pune in the year 2000 and the other at BARC in the year 2003. NCSC organized a national seminar at Labour India Educational Research Centre, Marangattupilly, Kottayam, Kerala, in the year 2005 following which it organized a national conference at INSA in New Delhi in the year 2006.

National Centre for Science Communicators, in association with Homi Bhabha Centre for Science Education, Mumbai organized a National Conference on 'Science Education-Challenges of Quality' The conference was open to science educators, communicators and scientists. There were about 150 people in the audience throughout two days and 22 speakers in all the four sessions put together inclusive of felicitation session to Prof.B.M.Udgaonkar.

The conference had three sessions that focused around the following themes; each of which had enough time for interaction.

- School Science Education: Challenges in Quality
- University Science and Technology
- Science Dissemination

We would like to thank Dr. Arvind Kumar, the then Director of HBCSE and Dr.H.C.Pradhan, the present Director of HBCSE for joint sponsorship and all the help rendered to make the conference successful. My special thanks are also due to Ms. Prema Prakash who has edited this proceeding.

**A. P. Deshpande**

Chairman

Mumbai  
10th July, 2010

National Centre for Science Communicators

Felicitación



# *The Felicitation Function of Prof. B. M Udgaonkar*

## **Mr. A. P. Deshpande**

*Chairman, National Centre for Science Communicators*

Prof B M Udgaonkar is a multifaceted personality. He is often regarded as a 'science educationist'. Would that be appropriate? Well, he is certainly a science educationist but not *only* that. The injustice in confining him to this one field will become evident when we get to hear his erudite comments on various issues, some far removed from the field of science education or even education in general. He is a dedicated scientist who has earned a worldwide reputation as a theoretical particle physicist. He is also a teacher *par excellence* having taught a variety of topics, not the least, reactor physics to a large group of original practitioners of that discipline in the country.

Prof Udgaonkar is an internationally recognised authority on nuclear disarmament, having played an active part in the Pugwash Movement that was awarded the Nobel Prize for Peace. He is a good orator, a prolific writer and undoubtedly, an excellent science communicator. He could be called *agent provocateur* in a different sense as he is able to provoke his readers. This aspect comes out vividly when one reads his Physics News editorials. One does not have to go beyond the Homi Bhabha Centre for Science Education

(HBCSE) to realise that Prof Udgaonkar is an institution builder. That he is a good nurturer of talent both individual and institutional, is apparent from the large number of students and disciples who have occupied prestigious positions both here and abroad. Besides the HBCSE, the Institute of Physics (IOP), Bhubaneswar and the Marathi Vidnyan Parishad (MVP) were put on firm footing by him. He started several novel programmes in the University Grants Commission (UGC) by establishing programme advisory committees in different subjects, to promote quality teaching and research in various universities in India.

Prof Udgaonkar has the unique ability of spotting the right person for the right job. Were it not for this extraordinary faculty of his, one would not have seen scientists like Abhay Ashtekar, Mustansir Barma and Sanjay Limaye where they are today. His command over the English language is superb and he has strived to develop it right from his school days. Prof Udgaonkar is a thinker with wide-ranging interests. Far from being just a laboratory or an armchair scientist, he has moved extensively in society and his thoughts on 'science and society' are well appreciated. At a casual encounter, one may find him to be a rather serious introvert. But once you get to know him well, one discovers the witty and even mischievous side to his

persona. Above all, Prof Udgaonkar is very honest and transparent in his personal and public dealings. So how would one finally describe him? Perhaps, simply as *a fine human being*.

Prof Udgaonkar has always shunned publicity. He has preferred to do his work patiently and diligently, away from the limelight. That is perhaps the reason he has remained unknown to many, and none of his anniversaries were publicly celebrated. The National Centre for Science Communicators has benefitted from his advice right since its inception. So, this centre along with the Homi Bhabha Centre for Science Education, which is a brain child of Prof Udgaonkar, decided to felicitate him on his completion of 80 years of a very fruitful and accomplished life by organising a national seminar on 'Science Education—Challenges in Quality'. We are indeed grateful that he readily gave his consent. Heartfelt thanks to you, Prof Udgaonkar.

### **A Formal Introduction of the Chief Guest, Prof. M G K Menon**

by Dr Parul Sheth, Treasurer, NCSC

Prof M G K Menon is Advisor, Indian Space Research Organisation, Department of Space, Government of India and President of the Indian Statistical Institute, Kolkata. He has been the Director of the Tata Institute of Fundamental Research (TIFR), Mumbai, and has remained Chairman of Commission of Additional Sources of Energy and Secretary to the Government of India for the past twelve years. He has remained Director General of the Council of Scientific and Industrial Research (CSIR), and of Defence Research and Development Organisation (DRDO). Prof Menon has remained Member of the Planning Commission with a rank of Minister of State; Scientific Advisor to the Prime Minister; Chairman of the Science Advisory Committee to the Cabinet; Minister of Science and Technology, and also for Education, in the Government of India; Vice President of CSIR; and Member of Parliament, Rajya Sabha. Prof Menon is a Fellow

of all the three Science Academies in India, and has remained a member of various other reputed international academies. Prof Menon is the recipient of many awards. He was awarded the Padma Shri in the year 1961, Padma Bhushan in 1968, and Padma Vibhushan in 1985 from the President of India.

### **Mr. Suhas Naik Satam**

*General Secretary, National Centre for Science Communicators*

The National Center for Science Communicators (NCSC) is a science communication organisation with national and international reach. Its members include science communicators from various fields of communication including print media, electronic media, radio, planetaria, and science centres. The NCSC was established in January 1997 with a view to develop science communication in India. The centre provides opportunities for science communicators to explore and express their talents and creativity for better understanding of science, and recognises such talents. Presently, the membership strength of the NCSC is over 160 persons spread across the country.

One of the most dynamic campaigns of the NCSC is its intensive interaction with the teaching community to inculcate enthusiasm regarding science education and knowledge transfer of science. The Centre has been conducting Science Journalism courses in both Marathi and English. The NCSC has published a National Directory of Science Communicators and a National Directory of Science Propagating Organisations for easy access to information regarding science communication. The NCSC has hosted several conferences, as given below:

- The NCSC hosted its First International Conference of Science Communicators at the Inter-University Centre for Astronomy and Astrophysics (IUCAA), Pune in January 2000. The theme was *Public Understanding of Science*. Around 200 science communicators across the globe attended the event.



- The Second International Conference of Science Communicators was organised at the Bhabha Atomic Research Centre (BARC), Mumbai in July 2003 to felicitate and honour renowned astrophysicist and science communicator, Prof Jayant Narlikar. The theme of the conference was *Man and the Universe*.
- The Third International Conference of Science Communicators was held in Rio de Janeiro, Brazil in April 2005, the theme being—*Science Communication in Developing Countries*.
- In October 2005, the NCSC organised a National Seminar for Science Communicators on *Expanding Horizons of School Science Education* at the Labour India Complex, Marangattupilly in Kottayam, Kerala.
- A National Conference—*Vision 2026: Challenges in Science Communication*—was organised at the Indian National Science Academy, New Delhi. The conference was held to felicitate Prof Yashpal, a renowned scientist and science communicator on his 80<sup>th</sup> birthday on that day. The conference was inaugurated by Dr A P J Abdul Kalam, President of India on 26<sup>th</sup> November, 2006.

We have assembled here today, for the National Conference hosted by NCSC in association with the Homi Bhabha Centre for Science Education, Mumbai. The theme of the conference is *Science Education: Challenges in Quality*. It is being held to honour and felicitate Prof Udgaonkar, the eminent scientist and educationist, on the occasion of his 80<sup>th</sup> birthday which falls on 14<sup>th</sup> September, 2007.

### **Dr. Savita Ladge**

*In-charge, Chemistry Olympiad Cell, HBCSE*

I would like to speak briefly on the genesis and current activities of the Homi Bhabha Centre for Science Education (HBCSE). The genesis of HBCSE can be traced to the late 1960s when a group of scientists from the Tata

Institute of Fundamental Research developed interest in the problem of improving the quality of science education in our country. These scientists voluntarily took the educational programme to schools of the Brihanmumbai Municipal Corporation (BMC) and to rural Madhya Pradesh. As the activities expanded, a strong need was felt for institutional support to carry out this task in a systematic manner. Thus, in July 1974, the Homi Bhabha Centre for Science Education was formulated as a constituent unit of the Tata Institute of Fundamental Research (TIFR). Grants were received from the Sir Dorabji Tata Trust, which supported the centre for the first seven years. Later, the Department of Atomic Energy undertook to support it as a part of TIFR. In fact, until 1992 the centre was located in the Nana Chowk Municipal School at Tardeo, Mumbai. In its first phase, the centre attended to the task of understanding the problems of first generation learners. The HBCSE undertook several programmes with BMC schools in Mumbai and also various tribal schools located in interior parts of Maharashtra. This first phase also saw the emergence of science education as an area of research. Even in the initial stages, a small number of young individuals joined the centre to pursue research in the area of science education. Today, most of them are senior faculty members at the centre. During this phase, the University of Pune and the University of Mumbai both recognised this area under their Faculty of Science. The vision and pioneering work done by Prof B M Udgaonkar and Prof V G Kulkarni—the founders of the centre—have helped in rooting this institution into research, and have also provided the direction for the future of the institute. HBCSE moved to its current campus in October 1992. With good infrastructure, our activities have become much wider than they were in the past.

As a part of the TIFR (Deemed University), HBCSE has a PhD programme in the area of science education in which fifteen research scholars are currently pursuing their degrees. We

have various courses as a pre-PhD requirement, including courses on the sociological aspects of education, research methodology, history and philosophy of science, and two foundation courses in science. All these courses give excellent exposure to research scholars to help widen their reading horizon.

The centre has also held several national and international conferences in the field of science education. Since 2005, a major initiative of the HBCSE has been the epiSTEME Series of Conferences which are held every two years. These are major international conferences on science, technology and mathematics education. Continual seminars, colloquia, and visits by scientists from across India and outside, create an excellent academic atmosphere at the centre.

With a good research background in the field of science education and grass root level experience with the school system, the second area of interest for HBCSE is the development of innovative curriculum and co-curriculum material. Several co-curriculum and popular science books for children and general readers have been brought out by the centre. HBCSE members have co-authored science and mathematics text books by the NCERT and the Government of Maharashtra. They were also involved in the NCERT's new curriculum framework. A highlight of the centre's curriculum development effort is an innovative primary and mathematics curriculum. The extension of this work to the middle school curricula has also been taken up recently. In near future, the HBCSE plans to develop e-material for science education.

The third important area in our activities is the Teacher Orientation and Science Popularisation Programme. We have extensive grass root level activities which are conducted throughout the year and which focus on education of the socially disadvantaged. All these courses for teachers are held either at HBCSE or at different locations all over India. Under science popularisation, we have two good exhibitions, one on *History of Science* and the other on *Gender*

*and Science*. We also have an exhibition for experiments called *Yes, you can do it!* conducted all over India as a part of the Children's Science Congress.

Since the year 1998, HBCSE has been at the forefront of the Science Olympiad Movement in the country. Today, it is the nodal centre for Olympiads in mathematics, physics, chemistry, biology and astronomy. This programme involves several stages and ultimately leads to the selection of an Indian team to participate in International Olympiads. The success of Indian teams is very well known. The Olympiad has led to the generation of quality questions which can be used by students of undergraduate level and also by teachers. They can be accessed from our website. The Olympiad has also led to the formation of Teacher's Associations in chemistry and biology. The Physics Association was already in existence and it is doing very good work. In fact, we use their network to conduct our Stage I selection tests. In the year 2001, HBCSE successfully hosted the 33<sup>rd</sup> International Chemistry Olympiad and in 2006, it held the 11<sup>th</sup> International Astronomy Olympiad. Currently, the centre is gearing up for yet another international event which is the 19<sup>th</sup> International Biology Olympiad, scheduled for July 2008.

As a natural sequel to the Olympiad programme, we have added yet another dimension—a programme known as 'National Initiative on Undergraduate Scientists'. In this programme, some of the best scientists and teachers from different scientific institutions are mobilised to motivate and nurture promising and talented Indian students for advanced studies and research in science. It is satisfying to see that the material, especially the experiments developed as a part of the Olympiad and NIUS, are being accepted by the existing undergraduate curricula, and are also getting accepted by major undergraduate curriculum initiatives that are coming up in the country. The twin foci of the HBCSE's activities in science and mathematics education are equity and excellence. With equal

concern for contents, method, research and field work, the Homi Bhabha Centre for Science Education aspires to have lasting and continuing impact on science and mathematics education.

### **Dr. Manasi Rajadhyaksha**

Organising Committee Member, NCSC and Secretary, Marathi Vidnyan Parishad

I am honoured to have this opportunity to formally introduce Padma Bhushan Prof Bhalchandra Madhav Udgaonkar born on 14<sup>th</sup> September, 1927. Year: 1995, Place: Oslo, capital of Norway. The Nobel Prize for World Peace for the year was given to Dr Joseph Rotblat and the Pugwash Committee. Prof Udgaonkar and other committee members were present to receive the award for having contributed in various capacities and playing a major role in the Pugwash Movement.

Way back in 1949, Prof Udgaonkar topped the MSc examination of the Mumbai University and got into research under Dr Homi J Bhabha at the TIFR. It is said that Bhabha had described Prof Udgaonkar as being one among his two best students; the other being Prof Harish Chandra. Between 1953 and 1960, Prof Udgaonkar was assigned the responsibility of building the core of the reactor theory group of the Atomic Energy Establishment, Trombay – now known as BARC. Prof Udgaonkar successfully executed the task, but his first love was for research in particle physics in which he did his PhD. He continued with his research work in particle physics at Lawrence Radiation Laboratory between 1960 and 1962. In the year 1963, Dr Bhabha again chose Prof Udgaonkar to head and to rebuild the theoretical physics group of the TIFR, and Prof Udgaonkar returned to the TIFR campus. Over the next two decades, in addition to starting the TIFR Graduate School in Physics, he initiated the Homi Bhabha Centre for Science Education, the Visiting Students' Research Programme, and the Western India Regional Instrumentation Centre. He was Chairman of the Board of Research in Nuclear

Sciences of the DAE, Chairman of the Atomic Energy Education Society, and Chairman of the Management Board of the Homi Bhabha Centre for Science Education. Prof Udgaonkar was also chosen to be the first President of the Indian Physics Association, as well as the first President of the Maharashtra Academy of Sciences. He was invited to be the President of Indian Academy of Social Sciences, the President of the Marathi Vidnyan Parishad, the Bharat Janavidnyan Jattha and many such institutions.

Prof Udgaonkar is the recipient of many fellowships and awards. His students are spread all over the world and have made distinct contributions in their fields of research. Not only for his students, but for many of us, Prof Udgaonkar's dedication to research and teaching, his commitment to the national requirements, and his nurturing and recognition of excellence at younger levels, are examples worth emulating.

### **Inscription on the Silver Salver presented to Prof Udgaonkar**

*"The National Centre for Science Communicators and the Homi Bhabha Centre for Science Education honour Prof B M Udgaonkar on the occasion of his 80<sup>th</sup> birthday, for his inspiring career in research and teaching, for exemplary commitment to the cause of education in general and science education in particular, in India, and for his role in the international efforts for nuclear disarmament".*

### **A message from**

### **Dr. Anil Kakodkar**

*Chairman, Atomic Energy Commission, delivered*

*by Dr Hemchandra Pradhan, Dean, HBCSE*

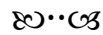
*Dear Dr Arvind Kumar,*

*I am writing this letter to you to express my respectful felicitations to Prof B M Udgaonkar on his 80<sup>th</sup> birthday. I was eagerly looking forward to participating in the function organised at HBCSE on*

12<sup>th</sup> September, 2007. I am however tied up with the visit of the President of the Brazilian Atomic Energy Commission to Mumbai and unable to participate. I had the good fortune to meet Prof Udgaonkar on a number of occasions, particularly in several programmes organised by the Homi Bhabha Centre for Science Education. I have also heard from several of my senior colleagues about Prof Udgaonkar's role in initiating reactor physics related activities in the then Atomic Energy Establishment, Trombay (AEET)

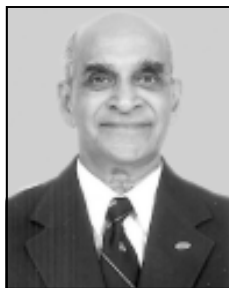
and all of them have very high regards for Prof Udgaonkar. We are all struck by his very clear way of looking at things, by his guidance and advice on issues involving several scientific and academic activities around us. The HBCSE is one of the important examples of his farsighted initiatives. I would like to use this occasion to express my deep and sincere gratitude to Prof Udgaonkar for everything that he has done. With warm regards,

Yours Sincerely,  
Anil Kakodkar



# *Felicitations speeches*

## *Prof. Udgaonkar and Pugwash Movement*



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### *Dr. P. G. Lavakare*

*Dr. Lavakare has been a physicist at the Tata Institute of Fundamental Research, Mumbai. He is a former Executive Director of the United States Educational Foundation in India and Advisor, Department of Science and Technology, Government of India on Physics / Space Research, Science Policy and Science Planning and Management. Dr Lavakare is also a Fellow of the Maharashtra Academy of Sciences*

As a student, I am happy to have two *gurus* on the dais. Both Prof Udgaonkar and Prof Menon have contributed to what I am today. What I learnt from them I do not know, but what they have taught me is something that I can only realise over the years. First of all, I would like to take this opportunity to pay my respects to my friend whose name I noticed as I entered the auditorium—Prof V G Kulkarni. Both of us were students together, in fact, we took our BSc together sitting in the same examination hall. Old memories came back and I thought it was an honour to be here on this occasion, and in my own way, pay respects to Prof Kulkarni.

The organisers had asked me to talk about Prof Udgaonkar's contribution to the Pugwash Movement. This is an occasion which I would like to make use of for telling all that I learnt from him on this particular aspect of the Pugwash Movement. I see a lot of youngsters, and for their benefit, let me say a few things about Pugwash so that it will bring out exactly what Prof Udgaonkar did. Reference to it was made earlier, but when I conclude, you will see what the contribution actually was.

So, what was the Pugwash Movement? In August 1945, the world had witnessed the horror and holocaust caused by the atomic bombs dropped on Hiroshima and Nagasaki. World War II had begun and ended with these two big bangs, but a new genie in the form of nuclear weapons had emerged. The nuclear arms race had begun and the Cold War had started heating up. Nuclear weapons were being developed as a deterrent against enemy attack. The larger the stock pile of nuclear weapons of a nation, the more immune it felt to an enemy attack. That was the reasoning of nuclear countries for continually getting into the arms race.

On July 9<sup>th</sup> 1955, almost ten years after the Hiroshima holocaust, two great men Bertrand Russell and Albert Einstein come forward to speak out openly, and warned the world about the perils of nuclear weapons. The Russell – Einstein Manifesto, which I would like the young people to read, was issued to attract the attention of the world community. Moved by this appeal of Russell and Einstein, a small group of scientists decided to hold a conference in July 1957, in a small fishing village named Pugwash in Nova

Scotia, Canada. The Pugwash Movement began with this conference. Strangely, this first conference was originally meant to be held in Delhi but the Suez Canal crisis prevailing then, prevented people from travelling and therefore, the venue was shifted to Pugwash. So you can imagine, had the conference been held in Delhi, it would have been known as the Delhi Movement to which Prof Udgaonkar has contributed. As of today, more than 55 Pugwash Conferences have been held and the whole organisation is known as 'Pugwash Conferences'. In 1995, the Pugwash Conferences was awarded the Nobel Prize for Peace jointly with the founder president Prof Joseph Rotblat, and I have just learnt that Prof Udgaonkar was present on that occasion. With that I conclude the Pugwash Movement and go on to the next topic, which is, how was India connected with the Pugwash Movement? How were Indian scientists and Indian science associated with it?

The Russell – Einstein Manifesto had referred to the world conflicts and the struggle between communism and anti-communism. These were the lobbies of the East and the West over the nuclear arms race—there was a big tussle between the communists and non-communists. In fact, going by the newspapers, even today the nuclear issue seems to be dominated by the communism issue.

I am not fully aware of the role that India played during the early Pugwash Conferences. However, I have read that Dr Homi Bhabha was invited by Prof Blackett to attend the 1961 Pugwash Conference, but he declined and requested the nomination of Dr Vikram Sarabhai in his place. Dr Sarabhai took a lot of interest in this movement, and in fact, established the Indian Pugwash Society to work with the Pugwash Movement. My association with the Pugwash Movement started in the early 1970s. I was introduced to this movement by eminent scientists like Dr Vikram Sarabhai, and more directly by Prof M G K Menon, and later by Prof Ashok Parthasarathi. They were the founders of the Indian Pugwash Society which is still operational

and supported by the Department of Atomic Energy for its activities. Several scholars like Prof Udgaonkar, Mr K Subramaniam (Defence Analyst), Mr Raj Mohan, Mr Jasjit Singh, Mr Raja Ramanna and others, were involved in the activities of Indian Pugwash Society and represented India on various occasions. In fact today, Dr M S Swaminathan, the famous agricultural scientist of India, is the Director General of the World Body of Pugwash Conferences. You can see that Indian science was very closely involved in the activities of Pugwash.

In the early seventies, I had the privilege of being associated with this society for a few years, again thanks to Prof Menon, and I was involved in organising some of the major conferences and workshops in India under the Pugwash umbrella. It was on this occasion that we had the golden opportunity of having the expertise of Prof Udgaonkar available for the Pugwash movement. I worked very closely with him and learnt a lot from his scholarly expertise. "Let facts be known to people", he would say, "don't say softy-softy, goody-goody things. If you are convinced about some thing, come forward and say it straight". During the early seventies, the developing countries, particularly India, through contributions of Prof Udgaonkar, made a direct impact at the Pugwash Conferences. Prof Udgaonkar in his characteristic forthright manner, contributed to shifting the purely East-West dialogue to the North-South conflicts. He focused his attention on the North-South conflicts on development—it was not just disarmament now, but they started talking of development. But first a brief comment on India's entry into the nuclear arena that had drawn the attention of the Pugwash Group.

India had carried out a peaceful nuclear explosion at Pokhran in 1974. (I am happy to see Dr Iyengar present here on this occasion). The Pugwash Group was alarmed and India was criticised. The Indian scholar community, particularly its stalwarts Shri K Subramaniam, Shri Ashok Parthasarathi and Prof Udgaonkar put forward India's position at a number of

Pugwash forums, and I think they admirably defended India's entry into the nuclear arena.

Let me now turn to Prof Udgaonkar's contribution to the Pugwash Movement in particular. As mentioned earlier, Pugwash had continued to focus its attention on nuclear arms and disarmament. Prof Udgaonkar however, was more connected with issues that were hindering the application of science and technology for development of developing countries. It is in this area of the North – South dialogue that Prof Udgaonkar's contribution to the Pugwash movement will be remembered for a long time. He strongly argued that the security of nations, particularly developing nations, is related to their socioeconomic development. If science and technology has a role in disarmament, it has an equally important role in contributing to the development of nations through its meaningful application. He highlighted the issues related to transfer of technology, the problems associated with it, self reliance and international collaboration as relevant to science and technology, and development. He openly challenged the Pugwash Group and felt that they seemed to be having an identity crisis relating to disarmament and development. To quote him in his own words, he asked, "What is the role of Pugwash in this situation? Are development issues only peripheral as many 'Pugwashites' think? Or are they the central issues faced by the world? Even from the viewpoint of traditional Pugwashites (Pugwash Conference scientists are often referred to as Pugwashites), the danger of nuclear conflagration is to be seen as arising out of conflicts between superpowers for domination. Domination over whom? The third world largely. So, to the extent that the third world becomes self reliant, the danger of nuclear holocaust should recede".

He had turned the tables on disarmament; turned the argument back from disarmament to development. He further challenged the Pugwash Group by stating: "The security dimension of development should not be considered as the only or even the most important reason why

Pugwashites should worry about development. The Pugwash movement derives its resolve thereafter, from the moral and ethical grounds since the days of the founder fathers who made the profoundly moving pleas of 'remember humanity and forget the rest'." (He was quoting out of the Russell– Einstein Manifesto). Prof Udgaonkar then proceeded to give an agenda to the Pugwashites when he said, "the two foremost issues of concern to the scientific community in general, and to Pugwashites in particular, outside the role of immediate research interest are and should be (a) How to ensure that mankind does not destroy itself by a powerful armoury of weapons and (b) How to ensure that the powerful tools now available to man through science and technology are actually utilised for eliminating poverty, want, and destitution from the face of the Earth, and more generally for the improvement of quality of life".

In my view, through these words, Prof Udgaonkar had set up a new agenda for the Pugwash movement. Increasingly, this agenda gathered momentum in the future activities of the Pugwash Conferences. The focus changed. In 1975, the Pugwash Group of Africa organised a symposium on 'Importance of Self Reliance in Science and Technology for National Development'. India organised the 25<sup>th</sup> International Pugwash Conference in Madras, in January 1976. At this conference, Smt Indira Gandhi addressed the Pugwash scientists and made a plea for a code of conduct for international co-operation for development. Pugwash had started paying attention to development. Prof Udgaonkar's agenda had become operational.

It was around the same time that the United Nations was looking at the issue of development. It was looking at the ways in which science and technology could be utilised for development of a large number of developing countries. The concern was that these countries did not have the necessary infrastructure for science and technology; how could they benefit from it? From India, Prof Menon was heading the United

Nations Advisory Committee for Application of Science and Technology for Development (UNACAST). The United Nations Conference on Trade and Development (UNCTAD) had also highlighted the importance of developing a code of conduct for transfer of technology. A consensus had emerged through these discussions that international co-operation in science and technology was essentially and collectively harnessing the benefits that could be achieved from application of science and technology. It was believed that such co-operation could solve the gamut of problems of developing countries relating to health, poverty and environment. International agencies started formulating collaboration projects in areas of science and technology.

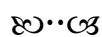
Around 1975, one such project was undertaken by WHO's agency in India, relating to malaria research. The way the programme had been planned raised doubts, suspicions and allegations that appeared in the Indian press, as well as in the Parliament. The then Prime Minister of India, Smt Indira Gandhi addressed the Pugwash scientists gathered at the 25<sup>th</sup> Pugwash International Function in Madras in 1976. She made a plea for a Code of Conduct in such collaboration programmes and asked, "Is the scientist also not responsible for the manner in which some programmes of international scientific co-operation for development have been evolved? In our country, there is the concern that on occasion, international scientific co-operation could result in developing countries being treated as guinea pigs for testing of new devices, techniques and chemicals. There is also the danger that apparently disinterested scientific projects undertaken on the basis of international collaboration are actually directed at other's objectives which may be prejudiced to the security and wellbeing of the developing country concerned. These are the problems for the Pugwash Movement to study, and Pugwash could promote some guidelines on the code of behaviour for scientists in international collaboration projects".

The Indian Pugwash Society decided to take

a lead from the plea made by the Prime Minister. Prof Udgaonkar stepped in and became the chief architect for drafting such guidelines for international co-operation in science and technology. Assisted by Shri Ashok Parthasarathi and my little role, the Indian Pugwash Society organised an International Workshop on the subject of International Collaboration in Haryana in January 1978. The guidelines that emerged from this workshop were later finalised by the Pugwash Council. They were to be disseminated among the scientific community, and the various world bodies of the Governments. These guidelines had clearly identified the role of developing countries, their scientists, the role of developed countries, funding agencies and multinational corporations. General guidelines for formulating international collaborative projects among scientists from various countries were also evolved. I will not give more details on these extensive documents that need to be studied carefully even today. So, Prof Udgaonkar should deserve a major recognition for his contribution in drafting these guidelines.

In 1979, these guidelines were incorporated in the final programme of action of the United Nations Conference on Science and Technology for Development. There, as I mentioned earlier, Prof Menon played a very important role. I was very lucky to have been nominated by Prof Menon to be on the international drafting group for preparing the action plan for the Vienna Conference. I was able to incorporate most of the Pugwash guidelines into the final Vienna Programme of Action. This is the least I could do for Prof Udgaonkar's valiant efforts.

I am fully aware that not everything that the UN conference recommends is actually implemented in totality. But it will always go to India's credit that we have contributed to this initiative on the Pugwash Guidelines for International Scientific Cooperation for Development—an initiative that was triggered and fructified by the scholarly and passionate commitment of Prof Udgaonkar.





## ‘होशंगाबाद विज्ञान’ के गुरु प्रो. उदगावकर



### **Dr. Anil Sadgopal**

*Dr. Anil Sadgopal has remained a Fellow at the Tata Institute of Fundamental Research, Mumbai. He taught education and was the first Head of the Department of Education, and Dean, Faculty of Education at the University of Delhi. He was President of Nehru Memorial Museum and is a Member of the Common School System Commission in the Bihar State Government.*

मैं हिन्दी में इसलिए बोल रहा हूँ, की जज्बात की बात है और जज्बात की बात मैं अंग्रेजी में नहीं बोलता हूँ। मैंने पहले भी आज दोपहर में कहा कि प्रो. उदगावकर मेरे गुरु हैं। मुझे उन्होंने प्रेरणा दी है, तालीम के लिए काम करने की। और बहुत चुपचाप ढंग से उन्होंने यह प्रेरणा दी है। बिना किसी प्रदर्शन के, प्रचार के, उन्होंने इस काम को किया, बरसों किया। यह उन लोगों से बिल्कुल अलग है जिन्होंने तालीम का काम करके उसके बदले में कुछ चाहा। इन्होंने कुछ नहीं चाहा। मुझे याद है जब इमरजेन्सी लगी हुई थी तब इन्होंने यह कहा की मैं आपके पिपरिया, जिला होशंगाबाद गाँव में आना चाहता हूँ। वहाँ का ‘होशंगाबाद विज्ञान’ का काम देखने के लिए। हमारे लिए यह बहुत बड़ी बात थी की पिपरिया जैसे इलाके में प्रो. उदगावकर जैसे वैज्ञानिक आ रहे हैं। हम इनके बारे में जानते थे और इमरजेन्सी का समय था। हम लोगों पर हर तरफ से हमले हो रहे थे। तो हमने मौके का थोड़ा फायदा उठाया और वहाँ के पुलिस को उनके बारे में बता दिया कि प्रो. उदगावकर जैसे व्यक्ति आ रहे हैं। जो इन्टेलिजेन्स के लोग थे, पीछा करते रहे, कहाँ कहाँ गए हमारे साथ। पिपरिया में एक कालेज है। बहुत छोटासा कालेज है। नाम का कालेज है केवल। वहाँ के कालेज टीचर ने कहा की हम मिलना चाहते हैं ऐसे वैज्ञानिक से। मिटिंग हुई। वे मुख्य अतिथि के रूप में बैठे हुए थे। मैं उनके बारे में बता रहा था। पता नहीं प्रो. उदगावकर को याद आ रहा है या नहीं। तो

मैं प्रो. उदगावकर ने ये किया वो किया, बता रहा था। जब मैंने अपनी बात खत्म कर दी तो कालेज के प्रिंसिपल ने मुझसे कहा कि प्रो. उदगावकर को तो बुलाइये। तो मैंने कहा कि वो बैठे हुए हैं। इतने साधारण तरीके से पूरी सादगी के साथ वे बैठे हुए थे। वे मुख्य अतिथि नहीं लग रहे थे। आज भी जितनी सादगी से बैठे हुए हैं - यह उनकी खासियत है। बड़ा काम करके भी साधारण दिखते हैं और इसलिए श्री. देशपांडे ने मुझसे कहा की आप इनकी विशेषता पर बोलिए तो मैं तुरन्त आया। ऐसे व्यक्ती के जन्मदिनपर बोलने से मुझे लगता है कि मैं सम्मानित हो रहा हूँ।

मुझे याद है की जब पहली बार टीआईएफआर में म्युनिसिपल कार्पोरेशन की टीचर ट्रेनिंग हुई, उस समय इस तरीके का काम हिन्दुस्तान में शुरू भी नहीं हुआ था। उस ट्रेनिंग को करने में उनकी बहुत बड़ी भूमिका थी। इसमें देहरादून से भास्कर पित्रे आये और उन्होंने म्युनिसिपल कार्पोरेशन शिक्षकों को किस तरह से नापना है, एक मीटर का स्केल लेकर - उसका पूरा प्रयोग करके दिखाया और टीचर्स ने भी किया। उस छोटे से प्रयोग से मुझे प्रेरणा मिली। इस काम को करने की और उस प्रयोग का आयोजन प्रो. उदगावकर के कारण संभव हुआ था। तब वेस्ट कैंटीन में बैठकर प्रो. उदगावकर के साथ लंबी बहस किया करते थे। उनसे मतभेद व्यक्त करते थे। उनसे कह सकते थे की हमें आपकी बात नहीं जँची, हमें सोचने का मौका दीजिये। वो हमारी

बात इतनी सौम्यता से स्वीकार कर लेते थे। यह नही समझे तो कोई बात नही, दुबारा बात करेंगे। यह पूरा माहौल जो हमको मिला, प्रो. उदगावकर के साथ लंबे अरसे तक उनसे हम सीखते रहे अपने आप। कोशिश करते रहे कि हम भी ऐसा बनें, जोकि आसान नहीं था। मुझे याद है कि एक बार वे बहुत परेशान दिख रहे थे। मैंने उनसे पूछा की क्या हुआ। उन्होंने कहा कि आज मैं बम्बई विश्वविद्यालय की एकेडेमिक कौंसिल की एक बैठक से वापस आया हूँ और उनको मैंने कुछ समझाने की कोशिश की, पर वो नहीं समझ रहे है। नहीं मान रहे हैं हमारी बात को। ऐसे ही यूजीसी की मितिंग से आते थे। इसी तरह परेशान लौटते थे। मैंने उनसे इस समय पहली बात सिखी की हिन्दुस्तान में अगर तालीम को बदलना है तो तालीम की व्यवस्था के अंदर बैठकर इस तरीके जे जूझना की आप चाहे कितना परेशान हो जों, कितने मजबूर हो जाएं, पर हिम्मत नही हारेंगे। उस व्यवस्था के अंदर घुसकर उसको बदलने की कोशिश करते रहेंगे। यह सबक प्रो. उदगावकर से हमने सीखा और होशंगाबाद विज्ञान शिक्षण कार्यक्रम की पूरी विचारधारा उनके यह सबक लेकर खडी हुई है। नहीं तो वह कार्यक्रम कभी नहीं खडा हो पाता। उस कार्यक्रम में अगर कोई खूबी थी वह यह नहीं थी कि बच्चों ने प्रयोग करके विज्ञान सीखना शुरू कर दिया था। गावं के हजारों बच्चों ने प्रयोग किए यह खूबी नहीं थी। खूबी यह थी कि सरकारी व्यवस्था के अंदर घुसकर हमने तबदीली की। मुझे याद है की जब सवाल तीसरे साल में उठा, १९७४ में, हमारे काम ते तिसरे साल में कि अब बच्चे आठवीं कक्षा मे पहुँच गये है और उनकी बोर्ड की परीक्षा होती

थी। अभी भी होती हैं। बोर्ड की परीक्षा होने वाली है और शिक्षक लोग घबरा रहे हैं की बोर्ड की परीक्षा में तो ऐसे सवाल पुढे जायेंगे जिनका उत्तर केवल रटकर ही आ जाता हैं, समझ के नही दिया जाता हैं। सोचकर नहीं दिया जाता है। तर्क करके नही दिया जाता हैं। तो बच्चे कैसे जवाब देंगे। शिक्षक घबरा रहे थे। तो हम लोगो ने शिक्षा विभाग के सचिव से बात की। कई बार बात की। अंत में उन्होंने बहुत बडी मितिंग आयोजित की। चर्चा हुई की बोर्ड परीक्षा में हम कार्यक्रम-जिसको हमने इजाजत दे दी है काम करने की - वहाँ के बच्चे तो अलग ढंग के गुणों को लेकर निकल रहे है औस सोचने वाले-समझने वाले बच्चे हैं, उनकी परीक्षा कैसे होगी। अंत में फैसला हुआ की बोर्ड की परीक्षा होशंगाबाद विज्ञान शिक्षण के सिद्धांतो से बदली जायेंगी - उनके हिसाब से बदली जायेंगी और नये मानदंडो के आधार पर बच्चों का मूल्यंकन होगा। और बच्चों को यह इजाजत मिली, उसका आदेश निकला जो हिंदुस्तान मे शायद पहली बार हुआ क्योंकि शिक्षा तो गंगा जैसी पवित्र चीज है। उसके परीक्षा को कोई छू भी नही सकता। इम्तहान को बदलने का जब आदेश निकला तो मुझे प्रो. उदगावकर की याद आयी क्योंकि उनसे सीखा हुआ सबक था कि व्यवस्था के अंदर जूझते हुए हारना नही है, बल्कि लडते रहना है।

मै इससे अधिक कहने के लायक नही हूँ। मैं केवल सिर झुकाकर, नतमस्तक होकर आपको सम्मान देता हूँ अपने दिल से। और मै मानता हूँ कि हमने अपनी जिंदगी में जो कुछ किया, होशंगाबाद जिले की मिट्टी में, वह सब आपकी प्रेरणा से किया।

# *Prof. Udgaonkar - A mentor of HBCSE*



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## ***Prof. Arvind Kumar***

*Director, Homi Bhabha Centre for Science Education.*

*Prof. Arvind Kumar taught Physics at Mumbai University for 12 years and then joined HBCSE in 1984. He became Director of HBCSE in 1994 and retired in 2009. Besides giving an impetus to many activities in HBCSE, the one which created a nationwide stamp in science Olympiad.*

Friends, I am very happy and honoured to recall my long association with Prof Udgaonkar in the capacity of his student, and pay my respects to him on this occasion. Perhaps our organisers expected me (and I am a part of the organisers) to speak about Prof Udgaonkar's association with the Homi Bhabha Centre for Science Education. But this evening, I am going to recall my personal association with him; my personal reminiscences of days before HBCSE even came into being. This is a rare occasion for me to pay my respects to my teacher.

It is actually a flash back to July or August 1964 when I first met Prof Udgaonkar. I had just finished the training school and belonged to the seventh batch which was the largest batch with 70 to 80 of us. We were in a waiting hall; I have forgotten the venue, but it was certainly not TIFR or BARC. We were there because our allotment for posting after training school was to be done. In those times, TIFR was one of the options, and I had decided on TIFR for several reasons. One of the reasons was that we were told by some persons that while both BARC and TIFR were great places, you had to do what you were told

to at BARC, whereas, you could do what you liked at TIFR. I thought it would suit my temperament to do what I liked. So, although BARC was an equally good place to go to, I decided on TIFR. Another thing was the building. Before the training was complete, we were taken on a tour of the TIFR campus and the building was so superb; I had never seen a building of that kind as I had come from an old area of Delhi. It was just amazing for me. So, sometimes such trivial reasons or uninformed advice lie behind important decisions. I still remember the shudder that I experienced when I was told that Prof Udgaonkar and Prof Menon were inside. These people had already become big names even at that time, and you can imagine the kind of nervousness we trainees were experiencing. And I was so very keen on joining TIFR.

Anyway, I entered the room and Prof Udgaonkar asked me a few questions. Actually, our cognitive scientist at HBCSE should investigate this phenomenon. Why is it that I still remember the questions that he asked me 43 years ago? They were questions on quantum mechanics that I still remember very distinctly,

whereas, I could easily forget things that happened a week ago. I think Jayashree would be best disposed to explain this phenomenon. I also remember the questions of Prof Menon very distinctly. Anyway, it all went well and I got admitted into the TIFR theory group. The first lesson that I learned from this interview is what we at HBCSE and many of our friends practice, and that is, the attitude of the interviewer. The way Prof Udgaonkar interviewed us then—or even when he conducts interviews now—made the interviewees feel at ease, and it is simply amazing. That is one of the first lessons I learnt; how to interview, how **not** to make people uneasy and try to see what they know instead of what they do not.

I liked the atmosphere at TIFR from day one (it was August 1, 1964) and still do; it is rare to find such a place elsewhere in the country—very non hierarchical and informal. You could not tell at TIFR (at least then you could not) who the Director was, or who was a professor or a research scholar, and that is the great thing about the institute. It was also a thoroughly academic place. I cannot think of any other place in the country—though there may be a few more, IISc perhaps—where people sort of ‘eat’ science, talk science...! We used to talk physics in lifts and in corridors. We used to ‘eat’ physics in the canteen and talk nothing of other matters. We used to discuss physics while walking on the seashore there.

Another very important thing that I found at the institute, for which the credit goes to Prof Udgaonkar and other senior people there, was that it was a very cosmopolitan place. It did not matter to which part of the country you belonged. Incidentally, it was two years after I joined TIFR that Prof Udgaonkar came to know, quite by accident, that he and I shared the same mother tongue. It is amazing because at other places, people would know almost immediately the part of the country you belong to, the language you speak etc. During the course of a discussion, I was calculating something and used the mathematical tables which you instinctively tend

to do in your own language no matter what part of the country you are currently placed. So, while I was doing that, he suddenly found that I spoke Marathi too! He was quite amazed. So, I think that is a good lesson for any institution, to be so cosmopolitan that you do not care about which regions people come from, as long as you discuss good things. So, that was about TIFR.

I must record my gratitude to Prof Udgaonkar. Although he was not my registered guide (I was under Prof Virendra Singh and of course, had a great time with him), he mentored me all the five years that I was at TIFR, from 1964 to 1969. I would have series of sessions with him. I want to share with you one important lesson in these personal reminiscences. I am seeing some lessons that I learnt, or maybe he tried to teach me! During these sessions, I would say something and he would reply, “It may be right, but is it useful?” I would get rather irritated because I felt he should tell me whether I was right or wrong. Why is he asking whether it is useful? Much later, on reflection and after some experience, I would realise what a profound thing it was! In science, especially when you are doing research, it is important whether the work you are doing is useful in the sense of the subject. I am not talking about whether it is useful to society or anything of that kind. Is it useful in taking you forward in some direction or is it a discussion for its own sake? This is what he meant. It was an important intellectual lesson for me that in physics, it is not about whether you are right or wrong, but whether the way you are thinking is useful or not.

Then there was this statutory requirement at TIFR to go abroad after PhD and I dutifully did that. I always knew even when I was doing research that my heart was actually in teaching and therefore, I returned. The University Department had just started and Prof Udgaonkar was helping in the setting up of that department. Thanks to his recommendations, I got a position as a lecturer. The reason I am saying this is because it was indeed my transformation and I am really grateful to him for getting me into

Bombay University. Bombay University was a dreadful place in terms of infrastructure; even now it is so. It is not easy to get good rooms and one lives in less than satisfactory conditions there. However, it turned to be a great place, even better than TIFR *for me*, because it was at this place that I discovered myself, my teaching interests and my strengths and weakness; whereas at TIFR, I was under pressure to perform and finish my Ph.D. And I believe that is the greatest gift a teacher can give a student; to put a student in a situation where he or she can discover himself or herself, and I am really grateful to Prof Udgaonkar for enabling me this opportunity.

Having dwelled upon personal reminiscences, I would now like to come back to HBCSE and Prof Udgaonkar's association with it. The history of HBCSE is in fact, the history of its association with Prof Udgaonkar, and the guidance that he provided. I would say that everything that you see here, be it infrastructure, human resources, the values and style of functioning, the written and unwritten conventions we adopt here, in some way can be traced to Prof Udgaonkar. You heard from Savita about the working of the centre, about the grass root work, the teachers' orientation programme, and that was how it started with Prof Udgaonkar's guidance, and later, Prof V G Kulkarni took over under his mentorship. You heard about the large number of research scholars working towards a PhD in Science Education at the TIFR Deemed University. The origin or genesis of that is the work of Jayashree Ramdas encouraged by Prof Udgaonkar, on children's ideas about optics, how children view various concepts in the act of 'seeing' of images, of shadows. She did pioneering work in science education research in India. Her work was published in international journals and she also collaborated with the University of Leeds which was then, and is perhaps even now, a leading centre of science education. The various materials produced are a direct outcome of Dr Udgaonkar's encouragement of Dr Lagu who produced the

first material. Later, more was produced by a number of HBCSE members. The Olympiad and NIUS programme that began about a decade ago and about which you heard from Savita, have their genesis in the study circle which Prof Udgaonkar had initiated in the TIFR. He used to invite BSc students to the Tata Institute. The Olympiad is basically to formalise and institutionalise programmes for getting motivated students, and helping them to achieve quality and excellence in that subject.

On values, a lot of people feel a certain cohesiveness among HBCSE members when they visit this institute. That again is basically his value. So, Prof Udgaonkar's imprint can be found everywhere in HBCSE. It is really difficult for me to pinpoint after more than four decades of association, to recall the qualities of Prof Udgaonkar that I admire, and what it is that has influenced me and other members of HBCSE most. It is hard to say that because the impression is holistic. Yet, I was reflecting on it yesterday as to what qualities I can distill, and to my mind, two things about him emerged. One is the quality of mind, and the other, the quality of heart.

About the first, his intellectual approach to things is—putting it in the words of famous educationist Prof Krishna Kumar—more enabling than prescriptive. Prof Krishna Kumar, the eminent educationist and present Director, NCERT, while summarising the National Curriculum Framework document said that “this is not a prescriptive document but an enabling document”. I think these words suit Prof Udgaonkar very eminently. He is a person who does not tell you what to do or what not to do. His leadership is not at all prescriptive, rather, it is enabling. He just lays down various enabling possibilities and leaves it to people to decide what they want to do. In fact, the very wide spectrum of HBCSE activities including remedial education to the disadvantaged or the international Olympiads, to many people may look like very different things. On one hand is the very advanced type of subject orientation and on the other, content orientation or pedagogic

orientation. How can these co-exist in the same institute? It may look like a like a contradiction, but it is not because of the non-prescriptive approach to education that Prof Udgaonkar has initiated at HBCSE. You let people do what they want to. If they have a particular interest, they can follow it, and the institute basically provides them the enabling conditions to figure out how to do that. I think that is a great gift that Prof Udgaonkar has given to HBCSE.

Coming to the quality of heart; many of us can sing songs about social problems and social justice and the like, but when it comes to personal behaviour, a lot of us fail in these matters. In one word, I would say that Prof Udgaonkar is an enormously kind person. Kindness is very natural to him. His kindness is not in the sense of being patronising or flattering; in fact, he can be exacting and very critical, he can even admonish. In my student days, he told me a

number of times that “this is not the right way”, not only in physics, but in other matters as well. He often used to assert, “This is not right, this is how you should give a seminar, or this is the way you should speak” and so on. However, one knows well that if one gets on a wrong track, he will be critical, he will tell you a few things but ultimately, he is a very kind person, and I think that is very reassuring for people who work with him.

I would like to conclude by saying that the centre has already done a lot of good work as you have heard, yet, there are a lot of things waiting to be done. Let us say twenty years from now, if the Homi Bhabha Centre for Science Education becomes a leading centre for science education and a leading R&D institution—if not of the world then at least this part of Asia—I think that would be a very fitting tribute to Prof Udgaonkar’s life time work.



# Science and Intuition



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## **Dr. Padmanabhan Babu**

*Dr. Padmanabhan Babu began his career as a trainee in physics at the Bhabha Atomic Research Centre Training School in Mumbai. He completed his PhD from the Tata Institute of Fundamental Research, Mumbai. Dr Babu's academic career progressed at the TIFR from 1961 to 1989. He carried out research in various disciplines such as Cosmic Rays, Theoretical Particle Physics and Genetics.*

I will go back in time to the 1960s, the situation at the TIFR, and how I could fit in and become a student of Prof Udgaonkar. Like Arvind Kumar, I too went for the training school, and I was in the fourth batch. At the end of training school, we also had the same feeling that if we could join TIFR, not only would it be a great place, but we could do what ever we wanted to; whereas at BARC, we would be told what to do. But as it turned out, we found that out of three or four of us who wanted to join the theoretical physics group only one of us, Mr Pashupati, could join. Ramnath Kaushik, I, and perhaps Stephens were assigned to the cosmic rays group, but I was quite happy. There was an International Conference on Cosmic Rays organised by Prof Menon and I also had a great opportunity to work with Prof Yashpal. Soon, Prof Yashpal decided to spend a few months in Copenhagen with Bernard Peters. After he left, I was feeling at a loose end, but in the mean time I had attended two theoretical physics summer schools in Bangalore, thanks to Prof Menon. It was very generous of him to let me go and attend these events. I used to have many discussions with Mr Pashupati about some

aspects of theoretical particle physics and he suggested that it was a good time for me to do particle physics. So, I went back to Prof Menon. In those days, even though Dr Bhabha was the Director, he was unapproachable. I would have shaken hands with him only once. However, Prof Menon was approachable, so I went to ask him whether I could pursue studies in theoretical physics, and very generously, he consented. That was around the time when Prof Udgaonkar was getting back from United States (1963). I was excited about particle physics, symmetries, group theory and so on and very fortunate to have him as my teacher. There were several things that were unique about him; one was he was generous to a fault. He never told you what to do. He would let me do things my way, but if I went to him for help, he had all the time in the world to clear my doubts. The second important quality about him was his lucidity. When he gave a talk on any of these subjects, he was extremely lucid.

The 1960s was a remarkable period for both the TIFR and the theoretical physics group. People from theoretical physics had gone places, for example, Rajashekharan had been to Chicago,

Divakaran to New York, and Jha to Stanford and so on. They returned from various places with the experience from those schools by the mid '60s. And as Arvind Kumar said we ate, walked and talked science. It was a time of great excitement. Many of you may not know that Prof Udgaonkar was doing leading cutting edge research at that time. He had publications with Gell-Mann and I feel that that was the period which he enjoyed most, even though he might have gone into education afterwards. It was a period of doing science for science's sake. It was something which we all enjoyed, but with time, he probably felt that something new, something not just for science but for the country, should be done. He could have gone in various directions. He could have joined the Government and become a Secretary. Instead, Prof Udgaonkar decided to direct his efforts towards science education.

Coming back to my personal experiences with Prof Udgaonkar, I would like to narrate a specific incident, one in which I had the fortune to see his insight. Sometime in 1965 or 1966 there was a talk in Bombay, by a well known biologist on the Methods of Science. I do not remember the name of the scientist right now. It was a very well organised talk and the scientist went on to describe in great detail, the methods of science, how science is carried out, what are the ways or paradigms used in carrying out science etc. He made it sound as if he was just uncovering, going from step 1 to step 2 to step 3 to step 4, as though it was a logical sequence. At the end of the talk Prof Udgaonkar asked me one question. "Where does intuition fit into all this?" It was a remarkable observation because much of science is done not in the way the scientist had described; rather, it is done by intuition. I can give several examples.

It is said that well known mathematician Ramanujam used to say that whenever he had a problem in his mind, he would sleep on it and a Goddess would come and tell him how it must be done, and he would get the solution. This was the way he described it. He lived the problem. It was as though the problem occupied his mind till he found the solution. I would like to give

one more example of this intuition or living with the problem, which solves the problem. I do not know how many of you have heard the name of Barbara McClintock, a well known biologist who in 1940s and 50s was concerned about the phenomenon of patterns on corn. There are various patterns on corn which are produced for reasons that were not clear at that time. She used to observe the specimen under the microscope, and it is said that she would see the pattern exactly. Finally, she figured out that it had something to do with *transposons* or 'jumping genes'. But it was completely crazy because then, the concept of jumping genes just did not exist. It was completely out of the blue and did not make any sense at all. But after twenty years, it turned out that she was right, scientists showed the phenomenon in *Escherichia coli* and finally found out the solutions. Why am I mentioning this? It is because Prof Udgaonkar had made this profound observation: "Where does intuition fit into methods in science?" So, the method of science is not something that is categorised.

In my personal experiences with Prof Udgaonkar, he has been extremely helpful to me. I spent only a short period with him as a student, from 1963 to 1966. I had joined training school with only a BSc degree and fortunately, Bombay University allowed BSc students to register for PhD. But they had a rule which said that you have to be a student for three years. I wanted to finish my PhD as fast as possible and Prof Udgaonkar said he would help me. He made sure that the University would insist on only two years instead of three to complete the PhD. Hence, I could join in 1964 and finish in 1966. In 1965, he provided me a great opportunity to go to summer school in theoretical physics at Bangalore. It was fantastic, because it was a place where a lot of scientists had come and I could learn a lot of things. Towards the end of my PhD, I had to go and work with Prof Gell-Mann at Caltech, again thanks to Prof Udgaonkar who had worked with him and was his good friend. Words cannot describe the kind of feelings I have for him—a remarkable man as a person, as a scientist and as an educator.



## *A father with whom I could argue*



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### ***Dr. Jayant Udgaonkar***

*Dr. Jayant Udgaonkar, son of Prof. B.M. Udgaonkar, is Senior Professor at the National Centre for Biological Sciences, Tata Institute of Fundamental Research, Bangalore. He has majored in Biochemistry and Applied Physics. He has remained the Dean at the National Centre for Biological Sciences since 1997 and Head, Research Activities at the same institute. He is a fellow of the Indian Academy of Sciences, and of the Indian National Science Academy.*

I was really in two minds about whether to accept speaking today or not. It is of course very nice to come and hear nice things said about your parents. This of course, is a good reason to be here, but it is also embarrassing to say those things publicly, which are sometimes best not said at all. Anyway, it has been very nice hearing nice things said about your father from important people, but I am getting used to hearing nice things said about him from many other people. Fortunately or unfortunately, the name Udgaonkar is a rare one and virtually any Udgaonkar you can think or hear of will be a relative. In the last few years, I have been going around the country and giving talks. I would be introduced to various people as Jayant Udgaonkar, the other person would say hello, and suddenly the name would strike him and I would find that I am being accorded a level of respect which I don't deserve; respect which I think is purely because of the surname. However, it is not due to my having earned respect for this surname, but my parents having done so. I have been very happy about that of course, and benefitted

a lot because it is nice to be recognised by your name even though you have not earned the right for that. But what has also struck me over the years, especially when I first joined TIFR, was that an ordinary staff member at TIFR had an extraordinarily high respect for him. I have no qualms about saying that there was no other professor at TIFR who had that level of respect from people who were in cosmetic maintenance or at the workshop etc. The reason is that he used to listen not only to students or colleagues, but even to the ordinary person in the institute. When I was young, I would sometimes go to the institute with him. He would give rides in his car to all sorts of people which most faculty members at TIFR would not even look at, then and even now, and this is something which is extraordinary about him. He really believes in human values and it is something I hope I will be able to learn at some point in my life. As I said, it is very nice having this surname and the respect that goes with it.

When I was asked to talk, I was perhaps expected to tell how my family upbringing helped me in my scientific career. This is not

something that is easy to answer. It is difficult to divide upbringing between father and mother, and actually in my family, my mother is more qualified than my father. My father is an MSc, whereas my mother is a PhD! The scholarship in the family was from the mother's side. Her father was a very well known historian and my mother has a PhD in Ancient Indian History. The two of them together provided the level of scholarship in the family, and an orientation towards an academic career which is a result of that. I think there was no doubt in my mind, or perhaps in their minds, that I would go into an academic career.

You heard right in the beginning, that my father used to stand first in class. I never stood first in class at any time and there was no pressure for me to do so. I was happy doing what I did. I didn't do too badly, but I was usually not at the top of the class, and there was no pressure on me. I think it may be partly because my sister used to stand first, so the pressure went there, if at all, but I don't think it was there either. But that is very important, not putting any pressure on the child for getting marks. Yet, there was some type of pressure to learn things in different ways, to read extra. The house would be full of books. We had more books than anyone else I knew of and I used to feeling comfortable among books. That is something which I got from both of my parents. What used to be most enjoyable when I was young was when my parents, my father especially, took me to Strand Book Stall or Popular Book Stall at Lamington Road, and let me buy whatever books I wanted. He would take me to the Homi Bhabha Centre's library at Nana Chowk and the people there would let me borrow books. He would also take me to the TIFR Library and borrow a couple of books for me from there too. For example, lot of my interest in the protein structure probably arose because of a particular book which I had borrowed more than once, a book by Dickerson and Geis which was nicely illustrated, showing

the beauty of protein structure. All that was very important and you could say that I could do this because of the advantage of being his son. If I look back, there were many other TIFR children, who used to be called TIFR brats or something, and who did not make use of this opportunity—the opportunity to really interact with people in TIFR and learn things from them.

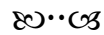
Right out of school, I had the opportunity to work with Mr Kalia in the electronics group, Dr P V S Rao's group. And I spent a few months with him learning how to make radios or transistors and these things are very important to get the self confidence of being able to do things. Mr Gambhir talked about that. I was there in the afternoon session and I think many of the speakers perhaps missed the main point. The main point about good education is to give self confidence to students—self confidence to be able to do things in their own. You can provide information, but information is not knowledge. It is very easy to get information these days and that is part of the problem. People do not realise that science is an activity where you have to work hard, to struggle to get new knowledge. These days, the ease of getting information via Google is spoiling young brains. Anyway, what really helped were these opportunities I got with Mr Kalia and Mr Rao's group, and working with Prof Pabitra Mitra one summer when I was an undergraduate student. These opportunities gave me the chance to realise what I was interested in, and what I wanted to do in life. Because I was his son, I got these opportunities.

I know my father comes across to many people as stern, perhaps someone not easy to get along with. And I think a lot of our relatives also think the same. I never had this problem of talking to him about any matter. I could argue with him, and he would consult me even when I was quite young. I got to see all the drafts he wrote for the Pugwash organisation before he sent them out. He would ask me for my comments and I would give them for whatever they were worth. It was really nice that he

respected my opinion even though perhaps, I did not deserve that respect. These things really matter in giving a person self confidence. So for one reason or other, I ended my educational phase—whether it was my school education, college education or home upbringing—with self confidence, and that is what mattered most to me in my subsequent independent career. I also learnt a lot about commitment from him. I knew, I could tell, I could see that he was

extremely committed about his work and I think that has hopefully rubbed off a little onto me also.

So these are the two main lessons I have learnt from him: *self confidence* of being able to tackle any problem, scientific problem in my case, and *commitment* to do your best towards achieving whatever you are doing or you are interested in doing.



## *Bhal means scholarship*



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### ***Prof. M G K Menon***

*Prof. M G K Menon was hard core scientist in TIFR, then rose to Directorship. Then we was Director General CSIR, DRDO, member of planning commission, scientific advisor to the Prime Minister, Minister of Science and Technology and Education, MP on Rajya Sabha, advisor ISRO, President of the Indian statistical Institution.*

Now I am going to stop calling him Prof Udgaonkar, instead, I will call him Bhal; that makes life simpler, and that is how we have known each other. We went to the same institute without knowing it. Both of us were in the same year up to 1949 at what was then known as the Royal Institute of Science, and now known as Institute of Science. But we did not meet each other. I was doing my Master's degree at the University of Bombay, and he was doing his Bachelor's. I left in 1949 to go to Bristol to work with Prof Cecil Powell on nuclear emulsion techniques and particle physics and Bhal left to join Homi Bhabha as his student. He never did any formal studies to try and get his PhD with Homi Bhabha. But he was a student nevertheless, imbibing a lot of what Homi Bhabha stood for, which was, *very high standards in science*; he studied theoretical physics and also had interest in the areas in which Homi himself had worked, which is elementary particle physics and so on. However, in Homi Bhabha's mind the important thing then was the Atomic Energy Programme (BARC) and building it up. So he sent many individuals abroad to various places and Bhal was one of them. Bhal

had come back in 1955 and that was the year I joined TIFR too. As he was sent abroad for research in reactor physics, his concentration was on this topic, and that is how his contribution to building up the reactor theory in BARC started. But over a period of time, he kept alive his interest in elementary particle physics, and as a scientist, he is known for his contributions to elementary particle physics with theoretical aspects. There are extremely important contributions he has made, particularly when he worked in California with Chew and Frautschi (Frautschi incidentally came for one of our summer schools in Bangalore), and the work that he did with Murray Gell-Mann; I think Babu has referred to it. It is one of the historic papers in terms of cross-sections and nuclei, and at very high energies—which is one of the crucial problems facing us today as we move into these high energies. What he and Gell-Mann had done was indeed a historic paper, and it is still a valid paper in terms of what it predicts, but I won't go into the details of all that at this stage.

What do I remember about Bhal? He came back from all those trips and built up the reactor group. There were many people to take over that

major task as it went along, so he come back to his first love, which was, elementary particle physics that he had learnt from Homi Bhabha. That was when he went to California, returned, worked at Argon, and that is where several people who have met him have written about it. Towards the end of his stay there, he was at the Edinburgh Summer School and a variety of other places, but he came back to India and that was the time when the theoretical physics group – which Babu has particularly talked about – had its very important developmental phase.

In the meantime, one also had a number of events happening including the 1961 Summer School which was a unique one with Murray Gell-Mann and Dick Dalitz, and the 1962 Summer School with Dick Dalitz and Sakurai. And that built a really very strong base, for what is currently going on in theoretical elementary particle high energy physics in the world; everybody got on board. Instead of being followers, one became current with the developments. When Bhal came back, he had a sizeable group and he really got them moving as a major force. That is why I say that he was a student of Bhabha, not formally in terms of attending courses and taking degrees, but imbibing from him, the spirit that motivated him; and that is the link between a *guru* and *shishya* that we always talk about in a *guru-shishya parampara*.

People have talked about it here—Arvind Kumar and Anil Sadgopal have talked about it – in terms of drawing out the finest qualities in a student. That is what he imbibed from Bhabha and projected thereafter; as an institute builder, and as one interested in national problems.

One of the standard questions asked in this country is, why don't we have more Nobel winners? The fact remains that individuals like him, who could have gone ahead with outstanding work in theoretical physics did not do so. They were concerned about national development and spent a good part of their time and effort contributing to ensure that it came about. This is what he imbibed from Bhabha.

Bhabha himself was in that category. Bhabha could have any day won a Nobel Prize if he had continued the type of work in which he was engaged, during the late thirties, early forties, in fact right up to the mid fifties. But he didn't. His real concern was the whole nuclear programme and the consequences.

So Bhal went on to other things, which you have heard about from a number of individuals. I certainly remember one aspect of TIFR that I must mention. TIFR had started with many things in the image of Homi Bhabha, and as he always said, it is the cradle of the Atomic Energy Programme of India. (We have a Chairman of the Atomic Energy Commission sitting here today). But more than that, TIFR also created many things in its own right. These included for example, all the work on electronics and instrumentation which went over to the BARC as the Electronic Division of the AEET, and went on to become ECIL at Hyderabad, and so on. So it created that type of development. The Technical Physics Division was originally set up in TIFR itself, but beyond that there were new developments which were taking place. I remember in the late 1960s, many discussions at TIFR were related to what we could do for national development. Very often, these discussions used to take place in the evening in faculty rooms where we used to have dinner together, and went on till late hours. There were many programmes started, of which one was the Bombay Association for Science Education (BASE) and other related to what has resulted today as the Homi Bhabha Centre for Science Education.

I have noticed that nobody has talked about Madhuriben Shah; she made a major contribution by providing Bombay Municipal Schools for the experiments that were done there, and they were youngsters. Bhal was interested in education, particularly education of the disadvantaged, education which related to the first generation learners and these things kicked off. The municipal schools were a good opportunity for the purpose; you have already heard how the

Homi Bhabha Centre for Science Education started from small beginnings—from programmes conducted in Girgaum, Grant Road, and Nana Chowk area. It was established in Nana Chowk, and later came here [Mankhurd], with tremendous support from Rustom Choksi. Rustom Choksi was one of those visionaries in a certain sense. As soon as he saw a good idea somewhere, he supported it to the hilt. After Bhabha's death, this institute became the Homi Bhabha Centre for Science Education.

Today we talk about the question of inclusion. We think that inclusion means getting in all the very huge numbers that we have in this country; people who are apparently left out on account of prejudices which are existing in society. There is a belief that this inclusion will occur by reservation without realising the real hardships and handicaps faced by them. These are the handicaps of the first generation learners and they have to be overcome. They indeed can be overcome when chances are given—there are many such opportunities now. Many will tell you that new programmes of Bombay University are essentially finding out that you have these first generation learners coming out on their own, without any special privileges being given to them, as those who are outstanding. But we have created a social milieu relating to peer pressures, on what is good for a student to go into. The standard group is medicine, engineering, MBA and then proceed on to money making ventures. But people like Bhal belonged to a generation where money was not the important consideration. It was scholarship. That is what he represents to me, scholarship. He has done many things of which a lot has been described in the souvenir which most of you would have received. Mr Deshpande has read out fully from the introductory part. It is true that you cannot call him just an educationist in science. He is first and foremost, a brilliant researcher who has done outstanding work in physics. He has gone on to be interested in national problems. To me, the mistake this country is making is to neglect education, and he saw it earlier that most of us

did. You can see all the motivated people like Anil Sadgopal here who went on to Hoshangabad; Arvind Kumar who went into education and is now Director of the Centre; V G Kulkarni and Lagu whom we talked about.

There is one other person whose 80<sup>th</sup> birthday we celebrated last year at Mr Deshpande's instance – Prof Yashpal, also member of the TIFR and one who attempted to introduce new technology, which was the television. The SITE experiment; the Satellite Instructional Television Experiment conducted in India was an effort to bring satellite telecommunications to bear through television, the opening of horizons for people in the far flung areas of the country. But now of course, it has become the typical soap opera, advertising, commercialised television which we see from the west.

One of the things I would say while talking about Bhal is that he was not a follower; rather, he was *throughout* a leader. What characterised him was leadership, whether it was in science education, or new education technology, or institution building.

Reference has been made to Pugwash many times. Dr Prabhakar Lavakare spoke about it extensively. I recall a very major conference on environment in Stockholm in 1972. The Prime Minister of the host country Olof Palme spoke about environment and peace, and the connection between peace and environment. The other prime minister who was present, was from this country—Mrs Indira Gandhi. She spoke about poverty and environment. Twenty years later there was the Rio de Janeiro Conference. It was called United Nations Conference on Environment and Development. Another ten years later, it took place in Johannesburg in 2002. In these conferences, three elements came together—Poverty, Peace and Environment. These three elements are strongly linked and one cannot separate them. One of the things that Bhal did was essentially, to continuously hammer this into the heads of those who were concerned in the Pugwash Council, that you cannot talk about nuclear weapon systems, or weapons of mass

destruction, if you don't include the whole question of social injustice that is characteristic of the world today...that lies all around us. Now I want to correct some of the issues. The first time there was a focus on the importance of development in Pugwash took place at the Udaipur Conference in 1964, and after that, it has always been there. Pugwash was something India was always interested in. That is because the Indian leadership from the early days, from the time when the atomic bomb was dropped on Hiroshima and Nagasaki, were aghast at this weapon of mass destruction. They were opposed to it and that opposition existed throughout the period of Jawaharlal Nehru. (I will mention about Pugwash in a certain different context in a few moments; it is an anecdotal reference to Pugwash). Nehru wanted to have a meeting of scientists from the East and West in Delhi, India. However, it did not happen because of the Suez crisis. Instead, the same group decided to hold it, at the invitation of Cyrus Eaton, in his place Pugwash in Nova Scotia. That is how it got the name Pugwash.

India was interested and Nehru was very interested in the consequences of nuclear weapons, beyond what was seen at Hiroshima and Nagasaki. That is why he had asked Bhabha and Kothari. Kothari was the one who produced the document on the impact of nuclear weapons. But there was a problem with Pugwash: they had already accepted the fact that a certain number of nations had nuclear weapons. They said that this is something that exists—the US, USSR, UK which was part of the Manhattan Project, France because De Gaulle insisted on having what he called *la force de frappe*, and later China. Now I do not want to read out anything in great detail, but I only want to mention Homi Bhabha—who had built up all the capabilities on a self reliance basis, covering the total nuclear cycle from exploration for uranium, to building reactors and the physics behind it—had in 1964 on the United Nations Day, given an address over the All India Radio. In this address he said that “the explosion carried out by China of a nuclear weapon, is a clear signal to those of us who have so far

abstained from doing anything like this that we have to reconsider the issue”. It was essentially fifteen months before Bhabha died. But the Pugwash Movement was somehow, all the time, interested in **not** talking about the importance of the existing powers to reduce their stockpiles, reduce testing such as the atmospheric testing. Rather, they concentrated on what they called the NPT (Non Proliferation Treaty). That was the concentration which they gave to the Pugwash Movement, which was not what it was when Russell and Einstein had originally drafted it.

Now, I will tell you a little story and then come back to the Pugwash Movement. Bertrand Russell was one of the strongest campaigners against the atomic bomb, and you will recall his famous speech, the Christmas address which he gave, and so on. There was a draft of the Russell-Einstein Manifesto which was to be finally signed by the individuals concerned, of which Joe Rotblat was the only one who was not a Nobel Prize winner *then*. He won the Nobel Prize later. That draft was with Frederic Joliot-Curie. It was brought personally by Eric Burhop from Joliot-Curie (because they were connected through the World Federation of Scientific Workers), and given to Cecil Powell who was also one of the signatories. But Eric Burhop had a lecture to give and could not carry it immediately to Bertrand Russell. So Cecil Powell asked me to take a train the next morning to London, meet Bertrand Russell and hand it over to him. So I carried that letter and gave it to Bertrand Russell. It is the only time I have met him in my life. Bertrand Russell was very disturbed because Einstein was very ill in America and would have died any time. So, Russell rushed the letter in its final form, signed by everybody, to Einstein. And then he heard the news on the radio that Einstein had passed away. He rued that the opportunity of there being something which bore Einstein's signature would no longer exist. It was one of the last documents—perhaps *the* very last—that Einstein signed in his life. And this document became famous as the Russell - Einstein Manifesto.

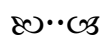
To come back, Pugwash concentrated on the

Nuclear Non-Proliferation Treaty. India opposed that stand completely; across the total spectrum, every one opposed it from Bhabha, to Sarabhai and down the line. I used to go there in the early sixties, as a representative because I was a member of the Pugwash Movement, to argue *against* the NPT in the Pugwash Movement. But somehow it never carried weight. They always kept saying that this exists – a *de facto* situation...the nuclear powers. You cannot in the present circumstances de-nuclearise the whole world. That was the struggle that Bhal had carried on, and I admire him for it. He brought it into focus at practically every meeting in the Council of Pugwash that it was not enough to talk about nuclear non-proliferation, it was important to ensure that the stockpiles were removed, don't exist, that the world is totally non-nuclearised.

I will tell you another small story. As scientific advisor to Rajiv Gandhi, I spent 30 to 40 hours on what was essentially his final speech and proposal to the Second Conference on Disarmament of the United Nations, in 1988. I travelled with him to New York where he presented the paper and left me to be with the press conference thereafter. He presented India's proposal on total nuclear disarmament.

So these are some of the issues which come up. When I say that Bhal is a leader, he is not only concerned with leadership in physics, leadership in school education—what the Homi Bhabha Centre for Science Education stands for—but the whole concept of popularisation of science; on transforming the way in which the Bombay University functioned. I remember the struggle because he was always sent as a representative of the TIFR to various bodies in the Bombay University. And I remember repeated Vice Chancellors and the problems they created in changing anything. In fact, I was quite surprised to hear Babu say that he managed to change three years to two years (for doing his PhD), because I generally had an impression that Bhal always came back very unhappy and very disappointed that they would not accept anything. That was true

even with the University Grants Commission (UGC), except that he did succeed in many things. He did succeed in the whole question of the Science Talent Groups. There are many people who have written about the way they happened to meet him for the first time—Abhay Ashtekar, Mustansir Barma so on, and how he encouraged them. He did change the Western Sophisticated Instrumentation Centre which was set up here, the UGC's Centres of Excellence Programmes; a number of things were done. Most of the people who have dealt with education have brought out that what is required is not talking down to people or explaining to them how science is done, but for *them* to think rationally, objectively, on a scientific basis, about life around and what they face. Science in daily life—this is what Jawaharlal Nehru had introduced in terms of words *scientific temper*. That is what Bhal has stood for throughout; particularly in setting up the Marathi Vidnyan Parishad and the work he did on that, and also the work he did in the Indian Physics Association and a whole range of institutions. I am not now going through the list of all he things he has achieved. It is indeed remarkable that one person has done so much in his life. He could have done something entirely in one domain as most scientists tend to do. I must say that the spirit which existed in TIFR in those days also meant that many more things were done. Science education was not the only thing that was done. He has contributed to the defence of the country; contributed to the new institutions which have been set up; the entire SAMEER structure which now exists a variety of places; The National Centre For Software Development and Computing Techniques at TIFR, which has now become NCST and which has been merged into CDAC, and so on. A variety of institutions were created by people and similarly, one gave a lot of individuals for nation building all over the country. I mention one of them – Yashpal – who celebrated his 80<sup>th</sup> birthday last year. In that sense, these are the people who have been true leaders and Bhal is certainly an outstanding one amongst them.





## Science and society



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### **Prof. B. M. Udgaonkar**

*Prof. B. M. Udgaonkar was hard core scientist from 1949 to 1965. Then his interest varied in the field of school, college and university education, nuclear disarmament, international peace, science movements in India and institution building.*

Friends and the extended family, I am very much overwhelmed by all that so many friends have spoken, and also by what they have written in the souvenir, and last but not the least, by those who are sitting in front of me all this time, having such unexpressed feelings for me. It is this kind of appreciation which has encouraged me to do some of the worthwhile things that I have done in my life. And I must sincerely thank all of you. I would also like to express my thanks to the unique institution that TIFR has been, and its Directors and colleagues who tolerated my excursions into different national domains which I thought very important.

Prof Menon referred to Madhuriben Shah, who was the Education Officer in the Bombay Municipal Corporation at the time, and we had considerable interactions with her because of the school education programme. She always used to say that "I want you people to get out of the 'ivory tower'." Now why leave the 'ivory tower'? In a vague way, because of a sense of social responsibility. When we talk about social responsibility, we hear a lot of people talk about it but find very few who dare to face the problems

which come. I got interested in this problem of education by two accidents, you may say.

One was the School Teachers' Orientation Programme at TIFR, which was being run by V G Kulkarni, and I used to interact with him. That programme ran into some difficulties because the funding agency in Delhi started playing its usual tricks. So, both Yashpal and I wrote to the Education Minister and we somehow salvaged that programme. At that stage itself, I felt there was so much to be done in education, but one cannot do it only in one's spare time. One has to have an institutional base for such education programmes. If, whether or not a summer school for teachers will be conducted this summer, is going to be determined by those sitting in Delhi and not appreciating the programme, then you can't go very far. So that is when I thought of institutional set up within the TIFR. Of course, my senior colleagues were worried whether one could have such a programme at all in TIFR. After all, it was an institution of the DAE whose mandate did not include education. Additionally, a separate Ministry of Education (now called Ministry of Human Resource

Development) in the Centre existed. So, I was asked to contact the Education Ministry and I met the education minister – may be in the month of March or April. He said, “Yes, it is okay. How much do you want?” I said, “About three or four lakhs a year”. He looked at the needs, and asked me to see if TIFR could give it. Finally, he cut it down to Rs 2 or 2<sup>1</sup>/<sub>2</sub> lakh and asked me when I wanted to start. I said the academic year would be starting in June, so start giving us this money from June. June came and went, July came and went, August, September also went. So, I sent a reminder. After some months, some Joint Secretary there wrote, “We cannot find your papers, could you send another copy?” May be many of us who have interacted with the government would have had this experience. So I sent another copy. Still nothing happened. In the meantime Rustom Choksi, Director of the Dorabji Tata Trust came to know about the reply and called me for a discussion. We went and met him. We talked for about two hours; V G Kulkarni and some colleagues were with me. At the end of the meeting he said, “We are giving you 15 lakh rupees for five years”. That is all. That is the difference between a Trust like Dorabji Tata Trust’s approach to setting up of institutions and the approach of the Ministry. That is how we started.

The other question is why we should have such a programme in an institution like the TIFR? It is a legitimate question. Many of my colleagues have put it to me. Most of them sympathised with what Kulkarni and I were trying to do, but very few really supported in the sense of participation. There is a certain amount of fear about one’s career among people, to some extent legitimate, but not always so. Anyway, we went ahead. Some of my friends did support and so here we are, and the centre has grown to the status that it has today.

The second thing was that around the same time, I had written to Prof DS Kothari, Chairman of the UGC, that I wanted to introduce in the institute, a simple exchange programme; not between our institute and abroad, but our

institute and our universities and colleges. So, he thought it ‘a good idea’. That is the usual response when anyone suggests something new, but that was never followed up by the fund-giving agencies and I had to follow it up with meagre support. They gave us support for that part of the programme which dealt with the Bombay college teachers, and the rest of it, that is, exchange between TIFR and University did not get any support. They said that if such programmes are good, we should have some resources of our own. That remained in my mind, and the apathy of the agencies which are responsible for education remained in my mind too. Some senior teachers from Bombay University came to see me around the same time. They were stuck up with their syllabus problem; it could not move. They asked if I could do something about it. Prof Menon was there at the first meeting with these people. I started taking an interest in it and finally succeeded in modifying the syllabus and the teaching patterns. The teaching pattern in those days was the so called inter-collegiate teaching. You move from college to college for different lectures. If the teacher is there, he gives the lecture and you attend it. If he is not there, you go to the next college and attend the lecture there. I am exaggerating a little, but that is how it was. So, we suggested changes in this pattern and in the number of lectures as well. At first, there were eight lectures per paper and that could hardly do justice to the subject; it would barely introduce the subject. I want to take a minute or two on this because one thing leads to another and you get entangled in the whole thing. So we said, “All right, we will try to see if my colleagues at TIFR will teach those courses if your teachers cannot give 40 lectures per paper. My colleagues were willing to do that, as also some of my people in TIFR. Then there was a problem of how the university would give the grant or honorarium of Rs 35 per lecture or whatever it was. But they said they could not give any honorarium if we took so many lectures. We said “Okay, we will do it without any honorarium”. One had to go

through these simple things and we started the programme.

When the new syllabus was passed, I remember there is a noting in my file, "Oh how happy I am!" followed by another note, "Have my standards of achievement become so low that I feel happy about it?" At that point, around 1970-71, I thought I was spending too much time on these outside educational matters and I should probably withdraw from them at least to some extent. I spent a few months at Princeton trying to take stock and learning new developments, and making some kind of progress for myself. But soon after my return, I found that I was taken as a member of the UGC. I took it a bit too seriously. Other members often, and with due respect to them, did not do so. We have a former chairman of the UGC sitting here and I hope he will agree with me. There were a few members from various universities on the Commission, but they were afraid to speak. They appeared to be there merely to protect their interests and their university's interest, nothing more than that. I am not doing injustice to most of them. I made some critical remarks at the meeting and found after the meeting, that a distinguished member would come to me saying, "I thought exactly like you but I did not say it because I feared that my university's grants may be cut". I do not want to take more time on such anecdotes, but this is the kind of system through which one had to wade. My friend, Freeman Dyson once described to me the "viscous drag" of social institutions. Incidentally, in the talk about scientists getting interested in societal problems, I remember once hearing Prof Wieman speak at one of the particle physics conferences. Outside the conference, he had a group of young scientists with him and he was saying to them, "Look, I have never worried about social responsibilities. I do only my work. I just asked him, "Prof Wieman, would you do the same thing if you were in India?" His very interesting reply was "If I were a Pakistani I would not do it. But if I were in India, I would not care about social responsibilities." He probably meant that India had a much larger

science community or 'non-community', whatever you call it. I can't help using this expression because I see that there are a number of scientists, but there is no scientific community yet.

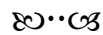
Then with one thing leading into another, I found that the science-society interface has so many dimensions in which a person with a scientific outlook can contribute. You cannot escape them once you start thinking about them. You just can't help taking part in at least some of them; whether it is scientific temper, or manpower problem, educational problem, science popularisation. The language in which you do the popularisation is important. Can you achieve popularisation in a language that 90% of the people do not understand? What does national development employ? Does it employ considerable amount of self reliance or does it employ foreign technology and being dependent on it? What are the forces at work when you buy foreign technology which goes under the name of 'foreign collaboration'?

This interaction with the system led me to present my paper in the Pugwash International Scientific Co-operation, which was well received there and which became the basis of the Plan of Action at the Vienna Conference. Such plans of action do not take you far; they remain on paper, but it is some educative experience. What education you get out of that, I do not know. There was one interesting thing in that inter-governmental conference. There was one session which was supposed to be of scientists, for scientists, and without the constraints that government representatives have. I think Prabhakar Lavakare mentioned it. Developing countries account for only 3% of the total R&D in the world. This must be increased, and the developing countries were asking for it to be increased by some 20% by the year 2000 or so. But the very people who were saying that developing countries must have more R&D were unable or unwilling to support such an increase. Even friends, scientists in the Scientist Session were not willing to support such a thing.

Referring to the remarks made earlier that when one leaves one's 'ivory tower' and starts indulging in such activities as I have done, does he not leave science and does he not leave physics? I don't know how many will agree. I have often worried about this question because if I did not have the training as a mathematician and a physicist, I would probably not be looking at the problems in the way I had started looking at them. So despite my training in these areas, I may not have continued to apply myself to particle physics. I tried, used, and applied it in some other domains. Does it mean that one leaves physics? I certainly left the 'paper producing' kind of physics, what my friend Babulal Saraf sometimes called 'routine fundamental research'. I do not know how many of you have heard this

expression from him, but it is a wonderful explanation of much of the work that many people do.

On an occasion like this, one always says nice things about the person who has occasioned the meeting. One never says anything bad about him or anything about his defects or shortcomings. I am only too aware of my shortcomings; it [accomplishments] has been at some costs of course, to my family and particularly to my wife. I had never been able to pay much attention to her emotional needs and other needs. Since this is a public occasion, and you are felicitating me because of my public involvements, I would also like to publicly apologise to her for what I have not been able to do. Thank you very much.



## Vote of Thanks



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### **Dr. Hemchandra Pradhan**

*Dr. Hemchandra Pradhan taught Physics at University of Mumbai. Then he joined HBCSE and became Director in 2009. He participated in curriculum development and text book committees of NCERT and authored books. He is a column writer and Vice-President of Marathi Vidnyan Parishad.*

I am honoured to be here as part of this function, a function so beautiful – like a *Mehafil*, and I think many of you would share the feeling with me I believe, that it should never end.

First of all, let me express my thanks to Prof Udgaonkar and Smt Dr Udgaonkar for agreeing to our request to attend this function, and for being with us this evening. The distinguished speakers today spoke about various facets of Prof Udgaonkar’s personality. He has been: a brilliant student, one of India’s earliest reactor physicists who contributed in a major way to the beginning of the nuclear energy programme in India, one who later played an important role in the Pugwash—the body of scientists for nuclear disarmament and peace, one who effectively put across on the world forum, the use of Indian science, a theoretical physicist of international reputation, a teacher *par excellence*, an educationist with interests spanning all levels of education and who founded and nurtured institutions, a mentor and guide who shaped great careers, a keen participant-cum-observer and witness to the development of science in India in the post-independence era, an accredited

evaluator and writer on science, what I call a balanced rationalist, and above all—a *great human being*.

We at HBCSE are a proud institution and proudly owe our pride to Prof Udgaonkar. We are deeply grateful to you sir, and also to Smt Dr Udgaonkar. Madam, we are so grateful to you for being with us today and for all the support you have extended to Prof Udgaonkar through the thick and thin in his life. Madam, we bow to you. We are deeply grateful to Prof M G K Menon, former Director of TIFR and Prof Udgaonkar’s close colleague for not only accepting our invitation to chair this function and specially flying from Delhi for this function, but for his wonderful felicitation speech. Sir, thank you very much.

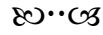
We are thankful to all the distinguished speakers of today’s felicitation function and also of the seminars—today’s and those to follow tomorrow. All the speakers spontaneously agreed to come here and express their feelings and views. We are indebted to them. There are so many distinguished visitors in the audience; Prof Udgaonkar’s relatives, colleagues, friends,

well wishers and all have especially come to attend this function. We are grateful to all of them.

It is my special pleasure to record our appreciation to senior scientists and colleagues from the Tata Institute of Fundamental Research, the Bhabha Atomic Research Centre and many other institutions. I have to specifically thank colleagues of the National Centre for Science Communicators who came up with the idea of having this function, and also colleagues from

HBCSE and the Marathi Vidnyan Parishad who toiled for this function for months together.

And finally, I am thankful to all of you for being with us in such a large number to attend this felicitation function. We are indeed moved by the spontaneous expression of love and respect for Prof Udgaonkar. On my personal behalf and on behalf of HBCSE, I wish Prof Udgaonkar and Dr Smt Udgaonkar many, many more years of life, full of happiness, health and fulfillment. Thank you.



Seminar 1:  
School science education -  
Universalisation with Quality





## The conference



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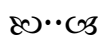
### **Mr. A. P. Deshpande**

*Mr. Anant Pandurang Deshpande has an educational background in Electrical and Mechanical Engineering. Although he worked in a well-known petrochemical establishment, his interests lay in literature, music, and science dissemination. This interest prompted him to write more than 600 articles, present audiovisual programmes, and conduct science gatherings. He has published nearly 30 books in different capacities: as author, editor, translator, publisher etc. Mr. Deshpande's role in shouldering responsibility as Honorary Secretary of the Marathi Vidnyan Parishad and as Chairman of the National Centre for Science Communicators is indeed commendable. He has received the FIE Foundation Award, and the NCSTC National Award for Best Effort in Science Popularisation, the Vidnyan Granthakar Prasarak.*

The Chairperson-of-the-session and delegates, I am very happy to welcome you to this conference organised in honour of Prof B M Udgaonkar. Of the three sessions that we have organised, one will be held this morning and two will be held tomorrow. The theme of the conference is SCIENCE EDUCATION: CHALLENGES IN QUALITY—a subject which happens to be dear to Prof Udgaonkar. Because the quality of science education differs from city to city, college to college, and university to university. There is a need for serious discussion on various aspects of this particular theme.

The subject of today's session is 'School Science Education: Challenges in Quality'.

Session II which will be held tomorrow, will focus on 'University Science and Technology'. There is a dire need to carry out research in colleges and universities which unfortunately, does not happen in our country. For that reason, Prof Udgaonkar chose this particular topic; education has been his forte all his life. Finally, session III scheduled for tomorrow afternoon will be on 'Science Dissemination'. The conference is organised jointly by the National Centre for Science Communicators, Mumbai, an institution that has been nurtured by Prof Udgaonkar since its inception, and the Homi Bhabha Centre for Science Education, Mumbai—the brain child of Prof Udgaonkar.



# Issues in school education



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## **Dr. Anil Sadgopal** (CHAIRPERSON OF THE SESSION)

*Dr. Anil Sadgopal has remained a Fellow at the Tata Institute of Fundamental Research, Mumbai. He taught education and was the first Head of the Department of Education, and Dean, Faculty of Education at the University of Delhi. He was President of Nehru Memorial Museum and is a Member of the Common School System Commission in the Bihar State Government.*

Friends, I am really honoured to have this opportunity to be present here on the occasion of the felicitation of Prof Udgaonkar who is my guru and inspirer. Today, I would like to flag five issues:

The first is, what is the meaning of ‘quality in science education’? There are several aspects of which I would like to mention a few. Is cognition, which is often considered as the very basis of science education, to be viewed as distinct from effective skill domains, or is there a holistic approach towards science education that is not limited or circumscribed only by cognition? How have the classical concerns like curiosity, exploration, critical thought, analysis, creativity and intuition changed over the recent years as a result of the dominant role of the *market* on the character of knowledge? What has been the epistemic impact of market on many of these concerned areas, which form the very basis of our understanding of the quality of science education? Have these ideas been appropriated? If they have been, and if that is our concern, how do we go about retrieving them? When we talk of quality in teaching science, we also need to

consider how values like equality, democracy and secularism fit in. When we talk of equality, it is not only in class or caste but also linguistic, gender, and normal body dominance in our ideas of who is learning science.

The second issue that I wish to flag is: Is the universalisation of quality education related in any way to the ideas of *inclusive* education? Diversity of various kinds—social, cultural, linguistic, epistemic in terms of knowledge, with different segments of population and normal body—is often taken to be the meaning of inclusive education. How has the hegemony of English as a language in our country impacted our ways of thinking? The use of English is often exclusive to large sections of our population, causing suppression of their articulation and their capacity to learn. How does it become an issue for quality?

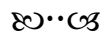
The third issue is about the education of our teachers. In hundreds of our B Ed colleges all over the country, the very framework of our teacher education programmes has been inherited from the erstwhile British system of 1880 or 1890. While the British system has changed and

advanced, we have retained our old framework. How do we come out of this old framework and build a new teacher education programme to meet the challenges we are concerned with?

The fourth issue is about the structure of our school systems. Our present school system is highly disparate and hierarchical, based on the principle of exclusion rather than inclusion. Can we improve science education in such a disparate school system? Ironically, will any improvement in quality not add to the existent disparity and hierarchy? Currently, we have the notion of 'Centres of Excellence' which forms the very basis of our education policy. We have

the setting up of the *Navodaya Vidyalayas*, *Kendriya Vidyalayas*, Smart Schools and various layers of higher quality schools in various states, as initiatives of State Governments. Additionally, on the 15<sup>th</sup> of August in his speech at the Red Fort, our Prime Minister announced the running of 6000 quality schools in each block. How do these notions of Centres of Excellence impact upon our quality?

Finally, the fifth issue is about how we can accommodate science education of the kind we are concerned with, when the state is abdicating its constitutional obligation towards the school system and allowing the market to take over.



## *Distributed class room*



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### ***Prof. Ram Takwale***

*Prof. Ram Takwale is an Emeritus Professor in the University of Pune, and the Yashwantrao Chavan Maharashtra Open University. Prof Takwale has a background in physics, but he developed an interest in education very early in his career. His contributions are mainly in the areas of Distance Education and Open University. He has been the Vice-Chancellor of Pune University, Yashwantrao Chavan Open University, and the Indira Gandhi Open University. He has received several national and international awards for his contributions in various areas of education.*

When I started my career as a university teacher, Prof B M Udgaonkar was my role model for various reasons. Firstly, it was because he is an *Indian* scientist educated entirely in this country, who has achieved national fame. Many others acquire their degree abroad and then return to become scientists. Secondly, he is a great teacher having social concern and attracted to solving the problems of education, particularly science education. Additionally, his contribution in the field of higher education, when he was a member of University Grants Commission, was that he added extension as the third dimension of higher education besides teaching. It was always inspiring to learn from him and follow him in various respects.

Today's topic is School Science Education: Universalisation of Quality. 'Education for All' is a movement that has been going on for a long time, but there is also a need to achieve *quality* school science education for all. How are we going to achieve this? It will include issues of universalisation, of quality and of making school science. What are the issues of universalisation? For this, we should consider big systems. For

example, consider the numbers involved in school education in Maharashtra: 1 crore 70 lakh students, 5 lakh teachers and 89 thousand schools. How are we going to reach them with our programmes?

Then, there is a phenomenon which Prof Sadgopal also referred to—that of tiering. There are international schools charging fees of more than a lakh rupees; there are private schools charging 30-50 thousand rupees; there are good public schools with government grants, good money, and which maintain a good standard; and finally, there are the Corporation and Zilla Parishad schools. So, we find that there is a tiering on the basis of fees.

Another point is about disparities and under-development—regional disparities, social disparities and the rest. How are we going to tackle them and make quality education available to all? An important issue is our large social system. Unlike higher education and professional education, the school system is not a professional system but a social system. In the case of the school system, you will find that every parent is involved in the child's learning

process. A large number of tutorials and tuitions are being taken, and what is their estimated number? If 5 lakh teachers are working in Maharashtra, at least more than that number will be working as private tutors earning their livelihood. You will also find at least 20 to 30 lakh parents involved in taking studies of their children. So, nearly 20 per cent of the population of Maharashtra is involved. If this is the scenario, how we are going to deal with the whole system and mobilise it?

In the case of science education, equipment is available in science laboratories in schools but no one does the experiments! 'Learning by doing the experiment' is only talked about in books. But what happens actually? We have to tackle all these issues in universalisation of quality.

The next point that Prof Sadgopal raised, is the question of quality. Now, quality has different perspectives. The first is *objective* or the *object oriented approach*—exceptional in quality or hallmark of quality. Sachin Tendulkar is a genius, an exception; Einstein and Newton are exceptions. Another is conformity to standards defined by experts or by society. We lay down certain standards and see whether one comes up to these standards or not. Conformity to standards is an objective aspect that also includes fitness for purpose. But what is the purpose? Or, is it serving the purpose? Again, purpose can be defined variously. The second approach is *value for money*. People pay, the Government pays, but is the education received value for money? The third approach is *transformative value*, which explores the extent to which education has transformed the individual, the school, the society, and so on. Our present programme lacks the right kind of approach for transformation and we are far away from universalisation of quality in this respect. Let us consider school education. Having said that the numbers are large; can we tackle the numbers that run into lakhs and not just a few quality schools here and there? We now have to decide whether we will proceed in

the conventional way that we have been following for the last 60 years or do something different.

What are the conventional ways? One is the factory model that involves a batch approach and a 'content orientation' pattern wherein personalisation is lost. The same book is to be learned by all, the same examination is to be taken by everyone, the same kind of programme of evaluation for everyone, etc. Because we do not have a personalised system of evaluation of students, individuality is lost and that is the factory model effect. Can we get rid of this factory model and achieve personalisation of the whole system? From content orientation, we need to change to quality and standard orientation. We have to move towards 'learning by doing'. How are we going to achieve it?

An important issue is the emergence of the information and knowledge based society. Every education system must cater to the needs of the emerging society. The present student generation is going to give creative ideas for the next 20-30 years. Are we going to change our education systems to make them useful for the emerging society, or we are going to continue with the same past practices? The question regarding our choice of model or approach for a future which will be based on information technology and various types of communication systems needs to be sorted out. If we have to solve the problem of 170 lakh students in 89 thousand schools in Maharashtra in some different way, our usual practices are completely useless. They will lead us nowhere and the problem will persist.

What are the alternatives? An alternative we suggest is the information technology based education. We are examining how one can use information and communication technology to solve the problem of large numbers, of quality, and of universality. The world is changing fast and a 'connected society' is being created; either you are connected to your mobile phone, or to the television, or to the internet, broadband, landline or computer. And yet, not all areas are

connected; students in the rural areas are deprived of connectivity. How can we create a connected world and give that benefit to every student in our country so that they get linked to other students? The 21<sup>st</sup> century is going to be the 'century of connectedness'. Hence, connectivity should be established as early as possible to extend opportunities for all students. This connectedness or connected society is creating completely different processes and practices, just as the industrial society had created processes and practices different from the agrarian society. We have been observing this phenomenon over the last couple of centuries. In the new information society processes which did not exist earlier are now coming up. Can we use these new processes to design a new system of education that will allow universalisation of quality school education?

Some of the emergent processes are technology-generated visualisation, digitalisation, and customisation. Customisation allows mass personalisation; that is, dealing with lakhs of students simultaneously and yet, marking the progress of each student, his/her personal card or folder being available for reference. Such technology is available and we can use it. We can no longer use the conventional approach; instead, we need a technology based approach to solve our problems in education. There are also other approaches such as self-organisation or "blog" as we call it. People across the world connect to talk on similar interests and exchange opinions. Such communication has become an independent process of organisation— independent of nationality, language etc. Self-organisation has indeed existed in the past in nature and in society, and now in the new connected society, it has arrived in a different way. Can we use this process of connecting students and teachers?

Next, the phenomenon of 'mass collaboration' is a good idea. Can we think of a few lakh people coming together for a common cause without invitation, to contribute towards

creating some resource which will be useful to everybody? The Open Resource Movement World Wide is spreading and through it, a number of things are being created. An option is to create an Open Educational Resource with contributions from each and every person who has something to contribute and making it available to everybody. This has been done by Wikipedia which is an Open Encyclopedia Research Resource available to everyone free of cost. If you wish to access the Encyclopedia Britannica online, you have to pay money. But Wikipedia is freely available and it has been created by the people themselves. More than 340,000 people have participated by writing or editing information that is also constantly updated. For example, when Anil Kumble scored his first century, this information was available on Wikipedia. When he continued 110 not out, that too was recorded immediately. Imagine a knowledge resource being updated to that extent! Such current processes and the newer types such as the Meta Databases can be used very effectively. One can create resources that people can access and create content or curriculum for students. As far as global standards are concerned, computers have to communicate with each other.

When we consider an institution or a programme, social scientists call them path-dependent; which means you follow a path starting with something, create something and once you go far ahead, you cannot retrace your path or change it. We experience this in our universities. Having chosen a particular path, you have to go through the whole process and cannot change your path. How can we create open systems where decisions could be changed, paths could be changed, new things could be brought in suddenly, or added at the very beginning? For that, you need a path-independent approach in creating resources that are helpful for development, for a large number of people. Now this is a very big and tricky issue. The questions posed at this stage are: what is the future scenario test model and what is the future

scenario dependent infrastructure that should be created by nations so that they can tackle the problems?

Cyber Infrastructure Development is becoming the central issue in many debates, and discussions and reports are available on this. We have to create a cyber infrastructure for the future *now* and start operating in a completely different way. We have been working on this scheme for the last 5 to 7 years and we have already created one platform with Maharashtra Knowledge Corporation Ltd. At any given time, it can easily accommodate a few lakh persons, and it can be multiplied to millions as well. Thus, we can have a completely electronic development. In Maharashtra, this facility goes to 3500 centres all over the state beyond the *taluka* level. Though the structure is available, it might need modification to suit our programmes. We will have to create a Cyber Infrastructure or an e-Platform on which students, teachers and schools can share their thoughts. Students have to be trained to interact independently, promote innovation and create with it, entrepreneurship. The programme under consideration for solving the problem of quality school education for all is virtual school and learning. Can we create a virtual school in which every school can participate? We have conceived a few independent programmes of which one is a *Prayog Pariwar Kendra* to be established in every school or outside it, where students can do laboratory work and also interact.

A distributed classroom where experts can talk to students is being developed. This already exists in 3500 centres from which one can communicate with anybody, at any time, and with any group. A very large number of students can be involved or reached using this concept. Whether it is appropriate for communicating education, is a matter to be evaluated.

Another programme is nurturing excellence and talent, and giving services. We are currently bound by the existing type of examination system. Is there an alternate examination system

which will promote innovation and creativity? Such an examination would be practical, involving fieldwork, and it would be the ideal system. Why not make this a part of the examination system? However, unless one demonstrates that it can be done on a large scale, and can become an effective alternative to the existing system, nobody will accept it.

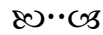
A significant programme is the 'Olympiad' created with the help of the Homi Bhabha Centre. We would like it to go all over Maharashtra. But it would be only for a select group of students. Can we think of a *mass* Olympiad as well as a *class* Olympiad? A mass Olympiad is like a mass marathon where everybody runs a certain distance, but a few manage to reach the higher or talent levels.

Regarding the Open Educational Resource, I am very happy to say that the Homi Bhabha Centre is taking the lead. There is also another aspect of it. Can we develop internet based, internet focused learning groups or learning communities from schools and colleges, where students can come on the network and start communicating? It is possible; at least on the type of network that we have in Maharashtra in 3500 outlets, and with telephonic connectivity in practically all villages. Then, there is another possibility; computers costing \$100 are now available only to developing countries. In our final project, we propose to have at least one class room with a \$100 (Rs.5000) computer for every student. The design and features will enable even a village child to use it. Can we allow that computer to be taken home and used for communication and operation? It is possible. We would like to implement a programme in which a computer is shared by a group of students for 24 hours by turns – a pair of students uses it first, then another pair and so on. That way, five to six families or groups can use the computer.

The issue is, technologically, what sort of content resources can be created? Open Education Resource is one, and Teacher Training is another programme that has to be

added. But one point is very clear – it is a very complex and challenging problem needing proper solutions which are available only in the 21<sup>st</sup> century model of education. For that, technology must be used; otherwise globalisation in terms of large numbers is not possible. Quality could also be thought of and definitely involved. In essence, we have to solve a simultaneous equation of six parameters:

quality, quantity, equality, cost affordability, speed of operation, and shared goal. The basic principle and value system will be practised in the collaborative system. We have associated with 10 to 15 organisations and institutions to adopt this solution. We will be launching this programme in one district of Maharashtra and then scaling it up. I am sure we will see some results within a year or so.





# *Deleterious impact of computers in Europe*



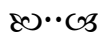
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## ***Dr. Anil Sadgopal***

*Dr. Anil Sadgopal has remained a Fellow at the Tata Institute of Fundamental Research, Mumbai. He taught education and was the first Head of the Department of Education, and Dean, Faculty of Education at the University of Delhi. He was President of Nehru Memorial Museum and is a Member of the Common School System Commission in the Bihar State Government.*

Prof Takwale has raised number of important issues including how to reach out to students using methods different from those we have been following in the 20<sup>th</sup> century. Incidentally, the numbers which Prof Takwale has mentioned in the present school system is half of what it should have been 20 years ago! More than half of our children are outside the school system. No more than 1/3<sup>rd</sup> are in secondary schools, and no more than 10% are in senior secondary school. The computed numbers are half of what they should have been at the elementary level. Numbers in the secondary and senior secondary levels should have been much more. The number of teachers and teacher training institutions lag behind by dimensions that are larger than one can imagine. According

to recent calculations, it has been found that in Bihar, the numbers will have to be increased by a factor of 3 because this state is lagging far behind. Whether the solution in terms of using Information Technology is right or not is a matter to be discussed. More important to me is not how to reach out, but what to reach out for? What is the purpose? Whether IT, by its notions of talent and its own notions of how it connects or does not connect, can really solve the problem is still a matter of debate. I am currently reading a book written by a European author, which has described the deleterious impact of using computers from an early age in Europe. Europe has resisted this idea for a long time. Whether it is right or wrong I do not know. Prof Takwale is an expert on this topic.



## *S & T education Vs Social issues*



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### ***Prof. Anita Rampal***

*Prof. Anita Rampal is a Professor of Elementary and Social Education in the Department of Education, Delhi University. She is a member of the Executive Council of NCERT and a member of the 11<sup>th</sup> Plan Working Group for Elementary Education. She has many interests; her special interests include Participatory Curriculum Development with a focus on Critical Pedagogy; Cognition and Communication of Science and Mathematics; and Policy Analysis for Equality in Education. She has co-authored several books including, 'Public Report of Basic Education', Nivruti Kauns, and Nivruti ka Hissa to name a few. Dr Anita Rampal has also produced films on women's education and participation.*

Prof Udgaonkar has inspired many of us scientists who started thinking about issues other than science when we moved out into areas like education and people's science. I feel it even more now than I did thirty years back that why is it that as scientists, we are closeted in terms of our concerns and what we think the role of science is? Being a scientist and having remained within science has brought in a lot of reflection about science itself, about people's science, science and society, and the sort of interactions that science can promote. That is the kind of plea and inspiration I would like to take along and question, what is happening in science education today?

When we talk about quality, there are notions—much more today than when we first started working in science education—that quality has something to do with excellence and with standards. Today, it is getting increasingly combined with social notions that are branded with inequality. When we talk of a quality school

or a quality institute, it does get branded and it stands out as an island. All over the world when people are questioning quality in education per se and not just in science education, one thing that emerges strongly is that: countries which have actually viewed quality in terms of reducing inequalities in educational outcome are those that have insisted that they will not allow curriculum differences. They keep the children together for at least 10 years in a comprehensive pattern of schooling, which means, you do not offer too many options, you do not track them, you do not make ability groupings, and you do not detain them. Nordic countries like Finland, and Japan and Korea stand out as countries which have actually achieved a bridging of inequalities right through the schooling system. Globally, when people look at quality in education, the issue that comes upfront is whether the system is bridging or reinforcing inequality. In our country, science has stood out as an island among other disciplines. It still commands that kind of

insulation of being something very special at the top of syllabus, the other subjects being less important.

In that context, historically too when science was developing, there were tensions between science for thinking and science for doing things (for action). This sort of science and technology dichotomy has existed for a long time. On one hand, there was Robert Hooke who made the pump and on the other, Robert Boyle who much later discussed thermodynamics. A kind of division existed between people who were doing or actively making things—the non-literate mechanics—and the scientists who were supposed to be doing real science. These dichotomies continued to the extent that even in England around 1817, there was a curriculum for scientification called ‘Science of the Common Thing’ which was run for poor children by missionaries. When there was a proposal to introduce science in primary schools (at that time science was not taught in primary schools), the authorities actually opposed it. They thought that it would go against the social order because this was science of the common thing whereas, real science was supposed to be “very abstract, selecting only those golden grains of excellence”. These are not my words but words used in 1817. This is the historical background of science in schools. Are we really moving against this? Do we view it in our context and say that we will continue to follow it? Even today, many of us are struggling with the science curriculum. We find that the discipline is still viewed in terms of science or scientists. How many scientists do we make? If only 6 or 7 percent of our children actually end up in higher education (not necessarily in science) then are we talking about that science in school or science for all? Such dichotomies of cognition versus affective domain have existed in our education system.

Research and studies on programmes for international students’ assessment which look at science literacy indicate that the most important aspect of doing and learning well is *motivation*. It is what you feel about it, how you feel about

learning and your own learning method. Motivation is greatest in those countries which insist that every one can do it right from day one. Japan has succeeded in this respect because every teacher feels that every child has the ability, but she must apply herself to it and put her mind to it. Group work and peer learning is encouraged in schools, and not just a few individuals standing out and giving pat answers. How do we ensure that science education becomes a collective activity and science really is for every one?

In the 1930s and 1940s, scientists like Bernal and Hubbard were looking at science for the millions, for people, for social betterment. Yet, science has not been questioned much, and science is what it has always been. You are only doing science for the people. I want to differentiate between *science for the people* and *people’s science* which in our country has had a kind of movement. What is science for the people? Do we really look at that body of knowledge differently so that we can accept all kinds of knowledge, every child’s knowledge? Can we culturally root that kind of knowledge? I will give you some samples from the new syllabus we have been working on at NCERT. I will also share with you the knowledge that much more has happened in social sciences about redefining of syllabus and curriculum and not as much in science, especially at the higher level. There was a challenge because primary science is meant to be environment studies. It is meant to be science and social studies integrated. How do you integrate science and social studies? It is not easy because each one of us has a background in a particular discipline and we tend to look at the world from our own discipline. It is very difficult to open up and actually think of what integration is. There is the geologist, the historian, and the biologist. Within biology, we have the botanist and the zoologist. When we sit down together to redefine and consider a subject which allows us, or a child, or a learner to understand the world around her, how are we going to facilitate this learning? It is extremely difficult.

Other concerns in the notion of having science for all is: what is the *language* of science? By language of science, I do not mean an exhibition of studies showing how the whole discourse of science developed over the past 200 years. The language of the writings, reports and recordings of early scientists like Galileo had some tentative qualities about them. There was curiosity and a feeling of wonder...“Oh! how beautiful” or “how amazing!” This was how people wrote. Gradually, the whole notion of objectivity – that science is seeking for itself, for its own reason – crept in. Because of that objective discourse, science started distancing itself. People were writing about it but distancing themselves from what they had observed. Science also tried to differentiate, there was a notion how you looked at the things. Unfortunately, that distance percolates down to the school level in the way we talk about science. That distance keeps the learner away from whatever she is actually learning or experiencing. This is not the way a student can learn. A learner in fact, needs an expressive language, not a transactional language which says that everything is known, and the thing is transacted.

When we talk of quality in re-doing or re-thinking our science education, the language is not just a language; in a way it interacts with our morality and our culture. The same is true about representation; what kind of visuals do we use? Are they conventional or of a much stylised type? We might have developed these visuals as part of our discipline, but why should we use them with the young learner in school? It does not work that way. Why not folk art which has a different perspective? If you ask a tribal artist to make something, you get a perspective that is totally different from the way modern western art developed. If the tribal knows that behind this wall there is a well, the tribal artist will make a wall and make a well on top of it, and something else on top of that. Perspective is knowing what lies there, not just seeing what is there. So there are many different issues that surface when we consider representation in science – not only in

terms of language but also in terms of visuals, especially when you are talking of learners.

Major observations that emerged after World War II were that science has no values and science is not neutral. Incidentally, Prof Udgaonkar is involved in issues pertaining to social responsibility of science, especially nuclear science. But does science allow this kind of reflection? The way science is taught today; does it show that there are areas which do have such controversial questions? Does science allow children to think about these questions? In fact, not only do we disallow such controversial or critical areas, but while teaching topics like temperature or force, we do not even share information. We do not allow a child the space to try the learner’s way of looking at the world around her, and to try out her own theories. Two hundred years ago, scientists struggled over various problems for years and decades and finally arrived at some kind of theory that was counter-intuitive – whether it was the notion of force, or space, or vacuum. But the way science is taught today discourages original thinking and promotes passive learning. Even if the science was done 200 years ago, it is presented as if that does not matter. This is a crucial area, and we have not seen any improvement in our science curriculum.

How do we look at Science and Technology Education? In the developmental context, what does it mean for developing countries? When we talk about water, whose water are we talking about? Are we looking at it from that context, or are we talking about water as some ethereal body that exists somewhere and scientists have to go and define it? These are our immediate concerns in education. One approach in learning is called ‘situated learning’ in which, as constructivists put it, we all learn as we take part in some activity and thereby transform it. What does it mean in science? Are we encouraging science learning in which there is a transformation or a community activity that brings about transformation, or is it merely learning something that is stated or given? From the situated learning perspective,

how does a learner look at an activity? How does she see the world around her and how does science engage with that? It is a collective process.

A major area which we find problematic is the *assessment* of learning. When we write down the objectives of science teaching, we mention many things but none of these ever enter our patterns or systems of assessment. So, why do we say that there are objectives of teaching science when they never come into what we think should be assessed and learned? Can we assess authentic performance? Not just some answer given somewhere, but authentic understanding, activity, innovation and creativity? How can we assess authentic performance that is not just based on a paper and pencil test? Even in the latter, what kind of questions do you ask? I give a few examples:

While planning the syllabus for classes 1 to 12, an idea was to have integrated science for classes 1 to 10. We decided to focus on a theme and pose questions which would not relate directly to the topics in the syllabus as is the usual case, rather they would be questions that would engage, or be leading or scaffolding questions. Thus, we would start with questions, proceed to key concepts, and then go on further to the resource material. This was the pattern that we decided to work on. However, as we went higher up in the grades, it became increasingly difficult. The task became impossible because of tussles among us, say, the chemists in our group had a tough stance on something—classic students will not be able to do this, or there is no pedagogy allowed to do that.

In the primary group we could do something and there was freedom because of the hegemony of discipline. In the primary school you just try to look at science and social studies. For example, on the topic of farmers we asked, how do you think a farmer should own land? Land was

related to growing food, food was related to people; problems faced by the farmer about fencing, or about fertilizers, and questions like these. History was related / restricted to 'look at your own parents or grand parents'. Children of that age need to know nothing about what happened 500 years ago; generation history is enough. History was, constantly looking at differences or similarities between generations and their experiences. While talking about school, we are trying to do it in a linked way and not in the original fragmented and reductionist way. When we introduce the topic of the human body, we discuss the parts of the human body and their functions. Similarly, when we look at plants, we discuss their parts and functions. It is correlation. The idea is basically, integration of language, mathematics and science. When you pick up a book you should not be able to tell immediately whether this is a science book or a language book. We should be able to do it that way.

This is a chapter from a mathematics book about time. You will notice that in any other regular mathematics book, you will find only clocks, or only the number of days in a week, month etc. It does not do anything more. The idea here was *time*; I can say that in our own culture there is much more meaning to time. What takes seconds? What takes minutes? What takes hours? What takes months? What are the kinds of activities that take so much time? We try to give a sense or a feel of time along with appreciation of labour and time. For example, how long you take to bath? A fun or comic element is also introduced. For example, there are some activities which should take just a few minutes; however, we are all familiar with long queues in public toilets. So, bringing that notion into the discussion is a part of our understanding of time, culturally.



## *Science experiments for visually impaired students*



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### **Mr. V. G. Gambhir**

*Mr. V. G. Gambhir was a faculty member at HBCSE, developed many experiments in different science labs of HBCSE, co-authored many books, participated in country wide class room programmes, in curriculum development and text book committees. Currently he is Director of Science Centre at Solapur.*

“It is not pitch dark in the field of science education, there is not enough light though” – was a comment by a very distinguished educationist thirty years ago in a conference on science education. Three decades hence, one can hear the same note from knowledgeable individuals. The cry has continued and may continue for few more decades to come. However, it does not mean that things have not changed at all. Some recent observations and experiences with some reflections on the past are worth sharing.

**Science Textbooks :** In the Indian education scenario, textbooks in general or irrespective of discipline, have enjoyed a unique position. In science and geography, they have been the sole governors of every other aspect of learning. Memories of science textbooks that we read during our school days are certainly not thrilling—very terse, knowledge-imposing approach, insistence on sophisticated language, and addressed to none! It was as if authors believed in the myth that ‘a science textbook has to be like that’. We were made to read these books

and it was no wonder that few really loved them.

Against this background, experience with one book is worth mentioning. In 1994, as a part of their Golden Jubilee publication series, the CSIR brought out a book on science experiments for children. There were three main characters – two curious children full of questions on whatever they saw or wherever they went, and a knowledgeable retired neighbour who never provided direct answers and who ventured to satisfy the curiosities of the two children. Exploration, eye for detail, relevance to life experiences, comparisons etc. were in-built in the text. Along with a ‘knowledge constructions’ approach, an appealing reader friendly style was an important feature of the book. Surprisingly, every reader irrespective of age tried to identify with one of the characters and think along those lines.

Today, it will be a pleasure for many of you to have a look at the latest science textbooks for Classes VI, VII, and VIII published by NCERT. Two children, *Bhoju* and *Paheli*, and their curiosities and ventures are the central theme of the books. The new books are drastically different

from the traditional dull and dry textbooks in their style. They also have a reader friendly style and a 'knowledge construction' approach. This certainly is a welcome change. More importantly, it is not some isolated experiment conducted in some corner of the country. Rather, it is the approach accepted at NCERT, that is, at the national level. Hopefully, it will percolate down rapidly.

**Treatment of Experiments :** Treatment of science experiments prescribed in the curriculum until recently, needs no comment. It is enough to note that they simply existed in textbooks—as if it was customary to have them—like an appendix, with no role to play. With not even a test tube available in schools, experiments “done” in textbooks using a bell for an evacuation pump, thistle funnel, or distillation flask, used to be a common observation. The style of those few selected experiments (like, air having 20% oxygen, or oxygen being essential for combustion) that were demonstrated (if at all they were) defeated the very purpose of using the science experiment in the learning of science. Predetermined observation and predetermined conclusion—as if there is nothing else to look at or to observe—continued as demonstration, that too with a 'don't touch it' warning. Why think of skill developments like observational comparison, designing alternative activities etc.!

Considerable change in these aspects can be experienced now in both, material and approach. Telecasts of series like 'Scope Vidyan' on *Balchitravani* are presenting activities directly to children, inspiring them to try it themselves. Mobile laboratory facilities of NGOs like Agastya International Foundation are becoming very popular in rural schools. Insistent demands from villagers resulted in rapid expansion of this activity from one laboratory to thirty two laboratories operating throughout the academic year in rural districts of Andhra Pradesh and Karnataka. Several local resource groups trained in the “Yes, you can do it!” activity of HBCSE have taken it further.

**Social Work at the Undergraduate Level :** In many places, this compulsory component has acquired stereotype forms like preparing a small patch of mud road in a village or in a plantation. Motivating students to undertake some other meaningful activity—like demonstrating science experiments in rural schools—as their social work assignment in the course is not difficult. It has been tried out successfully. A training course for selected undergraduate students was conducted from nearly 30 districts in Maharashtra and Goa. They were trained to demonstrate concept based experiments in an attractive participatory mode and were provided a kit for this. It was highly encouraging to note that after completing the given target of ten schools for every volunteer, many of them were happy to continue it further, and some are doing it even today. Several such 'agents of change' active in the arena is certainly an encouraging trend.

**Science Experiments for Visually Impaired Students :** To many persons it sounds like an odd idea, but the curriculum in schools for the visually impaired is the same as in regular schools. That is true with the science curriculum, too. It was a challenge to work with visually impaired students, especially regarding treatment of experiments. However, an arousal of sensitivity to the problem, the urge to do something, and the willingness to help of a group of students at B Ed College, was very encouraging. The entire exercise revealed that a lot needs to be done, and that it can be done, to give such students a feel for science and not the prescribed experiments alone. A meaningful handbook explaining the opportunities and possibilities has been planned collaboratively among the HBCSE, K J Somaiya College of Comprehensive Education Research and Training, and the Kamala Mehta School for the Blind.

The Open Educational Resources for Schools (OERS) is already operational in Maharashtra. Resources for students, teachers and parents—

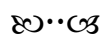
designed appropriately for each target group and reaching out to remote rural areas, is again a welcome sign.

The criticism that there is no opportunity in the present system to promote creativity and technological skills in students is fairly commonplace. The recently telecast thirteen episode television series *Hum Honge Kamayab* is yet another effort in this direction. Competition amongst teams for finding the best solution for a science related challenge, their different thinking lines, the struggle in decision making at every stage, designing and fabricating the assembly, and their struggle in tool handling, were all motivating and inspiring to child viewers. The programme is believed to be a model for future local initiatives and for similar events organised at city or district level. Let us hope that like quiz competitions which were unknown in our school days but very common in each school today, this activity also takes off in near future.

The message is clear. Help and contribution of many will be needed to change the gray areas in school science education. Satisfying is the fact that some beginnings have been made and a few more will be on the scene in near future. The vastness of the system calls for rapid spread and percolation.

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# Curriculum development



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## **Dr. Jayashree Ramdas**

*Dr. Jayashree Ramdas' interests include cognitive studies of science learning, curriculum development and evaluation of curriculum development programmes. She has published various papers in national and international journals. She is also member of several national and international committees.*

I would like to make only two points; the first is to thank Prof Udgaonkar and the second is to take some inspiration from his work. It was after my first year of MSc that I met Prof Udgaonkar. I knew that I wanted to work in the field of education and a family friend introduced me to Prof Udgaonkar. He asked me if I had read Piaget. Then, I did not know how it was spelt. I later went to the Pune University Library, looked up the catalogue and read that book. This was how I started my long journey.

I joined the Homi Bhabha Centre in 1976. The work and programme at the centre were organised by Prof Udgaonkar, Prof. V. G. Kulkarni and Dr Lagu in such a way that there was constant interaction between fieldwork, research, development of material for teachers, teachers' training, studying and analysing data, and qualitative assessments of current developments in the field. Because it was a small centre, it was possible for everybody to do all these things, as well as interact intensively with each other. We watched several hundred lessons conducted in class rooms, and after about 20 years of research, we began to develop the Homi

Bhabha Curriculum. The experiences in various fields, their structure and the interactivity helped me to go deep into the designing of a different kind of curriculum. For this, I am grateful to Prof Udgaonkar for having the vision to establish the Homi Bhabha Centre in which such research was possible; we had access to international research and simultaneously, there was a social commitment as well.

The second point is about the role of the Homi Bhabha Centre and the curriculum developed by it, in the larger curriculum development plan of the country. We decided to focus on curriculum development anew after many years of working on the existing syllabus. We knew that it would be a sort of model curriculum and would not be a part of NCERT, CBSE or any of the official curriculum development or implementation bodies. We wanted it to be an endeavor into which our research and experience were distilled. Many of us also serve on the text book committees of the SCERT, the Maharashtra State Text Book Bureau, and NCERT. In that sense, we found that the ideas developed during the designing of the

Homi Bhabha Curriculum did find reflection elsewhere. Text book committees in many states (SCERT) used these books to develop their own curriculum, and it also had an impact on the NCERT national curriculum framework.

For a curriculum that had been scientifically developed after collective research and field experience, and tested at every stage including intensive classroom testing even during the developmental stage, the next logical step would be to pilot test what was produced. A systematic pilot test of the curriculum in typical Government schools was needed. Here, we faced a strong road block. We found that it was not possible to do the testing in schools which voluntarily wanted to use this programme. There were about 25 such schools all over the country. It turned out that these schools were already experiment-oriented and interested in doing something. They asked for our curriculum and we sent it to them, but

we could not follow up beyond that stage. Secondly, we did not have a typical sample of schools to pilot test the curriculum. Here, we realised that there was something missing apart from the research and development that we were doing. Probably, engaging with the system and being able to have a meaningful dialogue on current developments in the school system was needed. By doing so, not only would we gain in terms of experiencing the current developments, but the schools would also be able to try out the curriculum. Many of us felt the need for this kind of advocacy. It seemed to be something you do at the cost of everything else, and we were not clear about how to do it.

Policy matters and advocacy has been Prof Udgaonkar's strong point particularly for various issues that he has been involved with. We would like to take inspiration from him to learn how we can engage with the system.



# Semiotics



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## **Dr. K. Subramaniam**

*Dr. K. Subramaniam joined the HBCSE in 1994 after taking a BTech Degree in Aeronautical Engineering and a PhD in the History and Philosophy of Science. His area of work includes mathematics education at school level, which includes development of curriculum and co-curriculum teaching material. He is involved in teacher training as well as in teaching students. His research work involves the cognitive aspect of mathematics learning, mental representation, and problem solving. He likes to make mathematics popular among teachers and students.*

Today, I will speak on our current work to address the challenges in mathematics education. The best way to describe the work is through the research we are doing—namely, restructuring the mathematics curriculum from the view point of pedagogy. The work done at the centre includes enjoyment of mathematics, development of material, research in mathematics education, and teaching mathematics at the MA and the PhD levels. What I want to talk about is research in mathematics education.

In the general ambience and mandate of the centre, we retain proximity to curriculum development and classroom processes. It is a feature of our research that has grown out of our curriculum development activity. The focus is on the restructuring the curriculum contents to make it easy to learn by all students. I do think that this is possible though it may not be easy. In fact, it is not easy to teach mathematics even at the primary level. Once the core mathematical structure is strengthened, core concepts and their connectedness are more visible.

Two areas of research are (i) beginning

algebra and (ii) fractions for understanding ratio and proportion. Why should beginning algebra be included in the curriculum? Firstly, it is in the universal curriculum of mathematics which all students should go through—algebra is a gate to mathematics beyond the primary and middle school level. Secondly, it is a vehicle or tool for generalisation in mathematics. Thirdly, it is a kind of an introduction or first encounter with symbolisation processes, which is also an important and integral part of mathematics. Symbolisation is encountered even at the primary level but in a sort of readymade way and not in a reflective way. But in algebra, the encounter is in a deliberate way.

Why fractions? Again, a fraction is a basic notation which captures the concept of ratio and proportion. That is probably the most widespread contact with real life situations. Multiplicative relations, and ratio and proportions underlie the world of measurement, the world of causality – how one measure causes another. It is a basic tool for understanding linear functions and much of the causal structure of the world. Fractions are symbolic

notations or the vehicles for communicating that concept.

We looked at the transition from arithmetic to algebra because it is important at the middle school level. There are a few important and fundamental points. The first is that, children have experience of computing with numbers and they now need to move from computing with numbers to computing with expressions. When we say we manipulate expressions, we simplify, factorise polynomials, solve equations etc. We are computing expressions which are symbols. Even numerals are symbols in their own right. So we compute with them but here we are computing with expressions. That creates some difficulties. Cognition and psychologically oriented studies have thrown some light on how children make the transition from numbers to expressions. Secondly, the culture of generalisation is not present in arithmetic but comes to the fore in algebra, which involves building formulae for functions in various situations and developing generalised representations. The culture of explaining and justifying the use—this is what algebra is used for and this is what children need to get introduced to.

Our approach is to develop conceptual and visual support for computing with expressions. We call this the Turn's approach; it is the first or elemental part of conceptual and visual support. Next, we build on the students' understanding of arithmetic. They already know a considerable amount of arithmetic and have a feel for numbers, but they may not be very good at computing. They may forget the addition or multiplication facts but may still have a feel for it, and it is important to build on this knowledge. The key concept here is *anticipation*. When children encounter a new situation, their previous knowledge allows them to anticipate what is going to happen, and it is important to hook on to this anticipation. This is what we have tried to articulate in the context of learning about symbolic expressions – both arithmetic expression and algebraic expressions. Thirdly,

we have tried to create an appropriate context for what we call reasoning *with* expressions. Second one was reasoning *about* expressions. It will be used to give symbolic tools to explain, justify, prove and so on. That is our approach in algebra.

Coming to the approach to fractions for understanding ratio and proportion; we started doing research during the seventies and the theory developed was called the 'construct theory'. Fractions are strictly speaking not mathematical objects; rather they are more of an 'application concept'. This is not one concept and it is abstract from point of view of what children can understand. So fractions stand for 'part-whole' relation for measure. Part-whole relation means you stick to proper fractions and do not go beyond, to a fraction which is greater than 1. Fraction is also represented by  $P/Q$ —the number  $P$  divided by number  $Q$ . It is the quotient of that division. It catches the idea of ratio and the idea of an operator. When you take two-thirds of some quantity, then the operator 'operates' on that quantity and scales it either up or down.

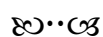
So, the question that we fix as a sort of goal in our work on fractions is: how does one distribute the sub-constructs over the running sequence? How do we really sequence the fraction assuming that we know these sub-constructs and have a good grasp of them? This is important for fractions. We believe that is the case. Our curriculum focuses too much on one sub-construct—the part-whole sub-construct—and then implicitly makes transitions which create problems for the children. So we need to make the transitions more explicit, connect the sub-constructs and put them in a proper learning sequence. Our approach here is to first shift the part-whole sub-construct to the measure sub-construct. We then develop in a systematic manner, different sub-constructs for fractions, focusing on the division and operators of constructs.

Now, a bit about the division sub-constructs. This is something which can be

easily grasped by students as well as teachers. Take any fraction, say  $4/5$ . You can think of it as 4 cakes shared equally by 5 children and  $4/5^{\text{th}}$  is each child's share. It is a simple but powerful idea. You can develop a whole lot of concepts using this idea of sharing. But one additional step will have to be taken; introducing the idea of a multiplier. While multiplying, you have essentially two magnitudes—the numbers 5 and 10. What is the multiplier that takes 5 to 10? The number 2; it scales 5 to 10. So it is really the operator concept. The multiplier idea turns out to be pedagogically very powerful. It captures a student's understanding of the processes of multiplication and division, and uses the fraction notation to capture. That really is the purpose of the fraction notation; it completes

your division operation in the sense that every number can be divided by every other number. That is the reason for teaching fractions for ratio and proportions. It is the real-life application of much of mathematics at that level. It makes mathematics more interesting.

Working with students and teachers, and getting a feed back from them is extremely important in gauging whether we are going in the right direction. Apart from these disciplines, we would also like to pursue other influencing areas in the future. One is *semiotics*—the study of symbolisation and meaning; how abstract ideas are to be arrived at by symbolisation. The other is the study of the work place where mathematics is used in some form or the other. That may also contribute to curriculum development.



## Question and Answer Session

**Question for Prof Takwale :** *The quality of education changes as the fee structure changes. What mode should we choose to overcome this problem?*

*(a) increase salary of faculty or (b) accept donations from corporate houses?*

**Prof. Takwale :** The problem we are discussing is rather a different one. Our problem is how can best education be made available to everybody? Can we create a social support, academic support, educationist's support? Can we establish common educational resources that are freely available? Forms that you can download, print, and copy as you like. Can we give training to people, to teachers to give support in learning anywhere – either at home or in the class room or the Y B Chavan Open University classroom? How do you use these resources effectively to achieve quality in learning and its application? If you can do that, then you will find that this quality can be improved. Only point is, you will need some sort of technology to make all the resources available to everybody. In a village, there could be a centre having a connecting point. People can walk up to that point, download or copy the material. How can we create such centres with social participation so that this expertise can reach the final destination? The problem now is more of a social or a local one. How can they reach the access centre or how is the access centre available to them? It needs technology, training, and also a new culture for using it effectively—it is a *learning culture* which needs to be developed rather than a *teaching culture*. Teaching would be used to support learning. The teacher's role will not be demonstrative, but supportive—to show *how* one

should learn. The learning process could be designed and developed in different ways.

A constructive study is another idea which we are trying to introduce. Here, 'situation development' means classroom situation, school situation, or family situation. How could the constructive theory or approach be used for effectively developing all these places? We are not speaking about capitation fees or more salary, but about the teaching and learning process, and resource development.

**Dr. Sadgopal:** *Will using technology based solutions leave out digitally backward and non-connected areas, students or societies?*

**Dr. Takwale:** We don't want to leave anybody out. Society should help those who cannot pay for themselves or the State should provide assistance. They could contribute Rs 5000 for a computer. The society pays or the government pays and makes the access point available. Why have internet and connectivity problems? Give them free access to internet. There are a number of countries where school children have free access to the internet. Can we not do it in our country? At least in certain very backward areas we can give it free, but there should be access. Approaches could be developed either locally or nationally, where you can give access to everybody.

**Dr. Sadgopal:** *Information versus education is always debated. Resources are a problem in rural schools where even getting a notebook is a problem. There, parents are not really involved or interested in the child's education. It is an important issue. Loaded question.*

**Prof. Takwale:** How is education imparted? Is there any communication? Communication could be in different ways and the information need not be just communication. Let information be discovered as well. Can we think of learning models in which people are exploring and identifying or learning? So the exploration type of approach could be adopted, like we have in the Pune district. We are reaching 15 *taluka* places and then multiplying them out. First, let the experiment be done. The second step is the exploration. At first, learn it by handling and playing with it, enjoy the equipment, and later go to the stage of experimentation, measurement and so on. There is nothing like information *versus* education. I am not getting the point.

Regarding the second part of the question about resources and getting parental involvement, the names of our programmes are *Virtual School*, and *Learner's Homes*. We would like to involve everybody. No doubt, this is a challenge. In fact, supporting programmes are available. How can information reach other houses? Education could be linked with skills or education might be use of technology or new methods to add value to activities—which is ultimately the developmental aspect. Suppose the students, particularly senior students of classes 8<sup>th</sup>, 9<sup>th</sup> and 10<sup>th</sup> start interacting with their parents and also in groups, possibly through group learning. The parent's group and teacher's group would form a platform or base involving them in education. Here you find us saying 'learning groups, developing groups, learning communities, developing communities'. That is how we would like to build up. Once you have an internet type of arrangement in it—where students can interact for at least 4 to 5 hours per day, whenever they have access, as a group, or in a school—then you will find that they will start interacting with other groups; and peer learning is always better than 'talked down' learning. Once the resources are available, things are easier. Everybody knows the experiment – *Hole in the Wall*.

You don't need teachers. People start

exploring once resources are available. The teacher will definitely accelerate the process of learning, make it appropriate and make it fast too. So the teacher's role is important, we don't deny it, but it is not necessary every time. If you have the resources, learning takes place in different ways. People have been doing resource based learning for ages. When natural resources were available, people discovered a number of things from nature and started using them. When such knowledge resources are made freely available, possibly, all people will use them in number of ways. That is the whole approach we are taking.

**Dr. Sadgopal:** *Is there a massive teacher training programme to enable teachers to teach in this innovative way, how will they adapt to this?*

**Prof. Anita Rampal:** I was talking about the struggle regarding the curriculum, but the biggest challenge is working with teachers. I am worried about the earlier comments that were made because I do not think we should talk about how any other resource can replace teachers. For learning, especially at the elementary level, it is crucial to have teachers who understand what learning is all about, how children learn and how to facilitate the learning process. So far as NCERT is concerned, for the last two years there was face to face interaction among teachers in our workshops, and teleconferencing, but this is not enough. The in-service programmes need to be restructured so that teachers are not just 'talked down' to. Lectures being given to teachers and engaging with teachers, allowing them the space to reflect on what they have been doing is a big challenge. It needs more time.

**Dr. Sadgopal:** *How much time does a child spend at school? If children learn much at home, why don't we think of training the parents or family members to motivate the children?*

**Prof. Anita Rampal:** We all know that children spend 4 to 6 hours per day at school depending on school timings. However, it is also true that children learn a lot everywhere. Yet, the school

is a process in which you are actually trying to help the construction of knowledge, or organised knowledge. We must try to get them to question what they are intuitively trying to understand, especially in science. We know that merely doing experiments is not really learning. Just because the children can see condensation or evaporation being done, it does not mean that they understand the concept. Understanding a concept and conceptual development needs a structured process that helps learning; the kind of experiments that they do, the discussion that takes place, the thinking process, and the elaboration that is done—all these are processes which a school has to do. It cannot simply happen otherwise. Learning, and teaching in learning has to be a more structured type of process.

**Dr. Sadgopal:** *Science education is a part of the overall education system. How can we then correlate the improvement in science education with the declining quality of life around us?*

**Prof. Anita Rampal:** True, declining quality of life and also of the public education system. We never had a more differentiated system earlier, as we have today. When we are talking about quality we have to resist this kind of differentiation that exists even in the government schools, and work towards having one good quality system for every one. Besides that, if there are some islands like public schools and private schools, that is different, but no country has managed to get universal schooling without public schooling or government schooling. I am very concerned about the quality of life, very concerned with questions of survival and inequality which we are facing today much more than we did 20 years back.

**Dr. Sadgopal:** *Dr Subramaniam, Dr Parul Sheth wants to know, why is it that all children are not good or comfortable with mathematics? Is it genetic or is it the teaching method?*

**Dr. Subramaniam:** You can guess my answer from what I said about the best accumulating from society. If you had a difficult experience

with something or you find some difficulty with say, subjects like mathematics, this is going to accumulate over time and form a vicious cycle. I think, dislike of or distance from mathematics comes from experience at some point, of either non-understanding or being put under too much pressure. The implication that you cannot do it (you are not smart enough), anxiety, and emotional response will have a strong effect on all cognitive processes. You cannot have a brain which is in a state of contradiction and emotionally under stress to learn something as abstract as mathematics. You need to be relaxed. You need to enjoy, relate to it, and you need to understand. There are many mathematicians who cannot compute.

**Dr. Sadgopal:** *Mr Gambhir, someone wants to know about the written examination for practicals that you talked about. Isn't there a possibility of multiple choice question books flooding the market and ultimately undermining this experiment?*

**Mr. Gambhir:** Over the last two decades, we have seen that we are very good at this. The moment you get the framework or the model paper, the very next day there are *Navneet* and other guide books available. But because of the fear that the market will be flooded by this kind of material and therefore not doing it at all, is not advisable. Secondly, just like other challenges it will be another challenge – that no question will be repeated, one can modify the questions so that simply remembering the sentence printed on page 13, bottom line will not help. One has to actually *find* the solution. Even if the market is flooded with this kind of material, there is no great disadvantage in it. Let the children read it. Even reading many questions of this type and selecting the possible answer is itself a kind of learning. Therefore, I think there is no reason to worry about that.

**Dr. Sadgopal:** *There is a question on which I want to seek help from a non-panelist. Dr Parameshwaran is the right person to answer it. The question is: 63% of our people are living in villages, so let us give them*



*food first, and then they will think of something else, like science or anything else.*

**Dr. Parameshwaran:** Give him food first; food for the belly and then food for the intellect. It is a vicious circle again. Quite often, food for intellect is required to extract the food from the belly because various divides like economic divide, social divide, knowledge divide, all reinforce each other. To say that bridging the economic divide before trying to bridge the knowledge divide, is not fully relevant; it has to be a simultaneous effort.

**Dr. Sadgopal :** *There is a question for Dr Subramaniam. Why and how do you sustain your interest in research in mathematics in the era of information technology for which, not giving how to learn mathematics meaningfully, is a necessity. Do you get it?*

**Dr. Subramaniam:** You are not saying why you should actively teach mathematics. Just put resources at their doors, give them the opportunity and they will learn by themselves. I don't think that is really true of mathematics. You need some system and you have the school system which is delivering the education. You may not have it a hundred years from now, I am fairly confident that will happen. But you will need *some* system, and at least in the system that we have today, teaching is an integral part of delivering knowledge and education. I agree with what Anita has said. Teachers are needed and I work within this system. It is likely that this system will be replaced by another one.

I am a little skeptical about the efficiency and the power of IT in delivering education, at least in the mainstream sense, in the schools sense. A school is a social arrangement. There is motivation and there is human to human contact that is necessary for learning. It can happen through the network also. But certainly, a network cannot be as efficient as the existing school system. Agreed, there are many things amiss with the school system, but we should try to correct them rather than think that you get that social advantage and an organised way of

learning only through the network.

You do not need to teach children how to use the internet. You just need to give them a computer, a mouse and the connection. They learn. But mathematics? Unlikely.

**Question:** *I think we are at the cross roads of mass education and class education. I would like to know from the panelists, the path we should follow to make India a superpower of knowledge.*

**Dr. Sadgopal:** I do not see any link between the first and the second statements. Secondly, I do not want my country to become a superpower of knowledge because I do not want my country to attack Iraq or any other country. Yes, I want my country to become a truly democratic, egalitarian, secular and enlightened society. But that does not equate it with being a superpower. The issue of mass education versus class education has been aptly answered before me by Anita and I can only elaborate.

The contradiction between mass education and class education can be resolved only by one method and that is by structural transformation of our entire school system; without hesitation or dilution. Such structural transformation has been awaited for decades, and it is in the direction of the common school system. There is no other direction. I am only adding to Anita's statement. There is no developed country, be it North America or Europe or outside these two continents or Japan, which has developed and reached its present status without a fully public funded, well functioning school system which is along the lines of our Common School System as recommended by the Kothari Commission. There is no other way of resolving the issue. If India or the government thinks we can make our country a historical exception to the global experience, I think we will be fooling ourselves.

**Question:** *Quality means what I get out of studying from class 1 to class 10 in my day to day life. Rural requirements are different from urban requirements. Then why is the syllabus the same for urban and rural students?*

**Dr. Sadgopal:** This question comes up in various fora. It arises out of our confusion about the terminology in education. We confuse curriculum and syllabus on one hand with text books and methods of teaching on the other. Let us not do that. While the curriculum and syllabus can be common for urban and rural schools, the pedagogy of introducing those very ideas or aspects of knowledge can be diverse depending upon the environment and upon the socio-cultural milieu. Therefore, textbooks can be different, methods of teaching can vary, and the teaching process can vary, while the curriculum remains common. Eventually, children get to a common level of knowledge through different paths or routes. Just think about it. This question has been resolved in the national curriculum frame work in 2005.

**Dr. Sadgopal:** One last question which will be a part of my concluding statement: *No speaker has addressed the issue of the hegemony of English.*

This is not totally true because Anita has treated this question differently. But let me respond to this person, who has said that I am not speaking my mother tongue—*Matrubhasha*. Let me tell you a story from my life in Hoshangabad district. I was visiting a school called *Chaandon* in the village of *Chaandon*. It is about 14 kilometres from the pucca road. The teacher there was an inspired person. On that particular day, and he was conducting an experiment with the children. The children had brought water from various sources: ponds, nallah, tube-well, a rivulet, and they were supposed to test which water was soft water and which one was hard water. The method was to make a solution of soap, add one drop separately in a container, shake it up and see how much effervescence arose. The children did that. The hard water did not produce effervescence and the soft water produced a lot of it. The children were working in groups of four and each group was excited by the effervescence coming out of their containers. They were talking excitedly in their local language, Bundelkhandi which is

spoken in North Central India. The text books are in Hindi, but teaching is in Bundelkhandi. There was lot of noise in the classroom as they discussed how to record it. Suddenly the teacher said to them, “All right, you had enough discussions amongst yourselves. Now record your observations”. Suddenly there was total silence. The excitement was gone. The children looked dumbfounded and started looking at each other. When he got no response he said, “जो भी देखा है वो लिखो” The children looked at him and asked “जो देखा वही लिख दे?” यही तो मैं कह रहा हूँ। “तो मैं यह लिख सकता हूँ की बाऊ मुक्का फसुक्का उठत है। मैं लिख दू?” “Yes, बहुत अच्छा होगा-लिख दो.” And the child was very happy. Every one said “ये तो लिख सकते है वो तो लिख सकते है” and they all wrote बाऊ मुक्का फसुक्का उठत है। बाऊ means in that pot, container, मुक्का means a lot, and फसुक्का means effervescence. That is the power of language. Children had understood, but they could not write in a language that was alien to them.

I once had an opportunity to help the Assam Board Of Education analyse their class X result. I found out that the majority of children who had failed had failed in English. I told the Chairman of the Board that it was not fair because the students knew their subject well but could not write in English. They did very well in Assamese, reasonably well in Hindi, but badly in English. The Chairman expressed his helplessness and said that it was the rule of the Board and these students had to be failed.

What should be understood is that learning and acquiring knowledge is not equivalent to expressing it in a language which is not your own. They are two different things.

I conclude with a story, again from Hoshangabad district from a village called *Junetha*. The teacher of that village met me in the weekly bazaar and said, “मैं आपको हमेशा कहता रहा हूँ की यह जो प्रोग्राम चलाया है, ‘होशंगाबाद विज्ञान शिक्षणका’ वह नहि चलेगा। लेकिन आप सुनते नही मेरी बात। मैं कितनी बार बोल रहा हूँ यह फेल हो जायेगा, और फेल हो रहा है।” I said, “क्या हो गया गुरुजी? क्यों इतने घबराये हो? चल के देखिये। आदिवासी बच्चे हैं, गौड आदिवासी बच्चे है। कुछ उनके समझमे नही आता, मैं उनको प्रयोग करने को बोलता हूँ, प्रयोग नही करते। मेरा मूह देखते रहते है।”

I said that I would go to his school the next

time and I went to his school. That day, they were doing an experiment mentioned in the workbook written by us. The students were given kerosene in one container and water in another. They were supposed to identify the two liquids using their sense of smell and distinguish between them. The teacher complained, "I am asking them to do this, but they don't do anything. They are not responding, or talking, or discussing among themselves. The whole project fails." So, I took charge of the class and talked to the children. I asked them where their villages were. How far had they walked? What happened on the way? Did they pluck mangoes from trees? Did they play *kabaddi* or *gillidanda* on the way to school? The children relaxed and told me stories. Finally, I said, "I have to go now, tell me, how will you distinguish between these two containers? Which one contains kerosene oil and which contains water?" Many hands were raised. "There are many ways of doing this" said the children. I was surprised because I thought there was only one way.

"कौनसा बताये?" asked the children.

One child said, "I will take drop of it on white paper and then wait for it to dry. The one which leaves a light yellow spot will be kerosene oil, and one which does not leave a yellow spot is water."

Another hand went up. "How will you do it?"

"I will compare the time it takes to evaporate. One which evaporates before the other is kerosene oil."

Yet another hand went up.

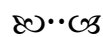
"We will mix the two. The one on top of the other will be kerosene oil".

And finally, one child raised his hand. One more answer!

"What will you do?"

He said, "Today is Wednesday and it is bazaar day out in the village. We want the class to be over, so we will take both the containers to the *bania* shop and ask him for which one he will pay money? The one he is ready to pay money for, is kerosene.

That day the children won, and the teacher whom we had ourselves trained and I, lost.





Seminar II :  
University Science and Technology



## University leadership programme



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### **Prof. Arun Nigavekar (Chairperson of the Session)**

*Prof. Arun Nigavekar is a well known educationist having a background in physics. He began his early career as Professor in Materials Science, Pune University in 1977. In 1980, he established the Centre for Advanced Studies in Physics, in Pune. Prof Nigavekar was Vice Chancellor, University of Pune from 1998 to 2000. Under his leadership, the University attained the status of 'University with Potential for Excellence'. He has been a former Chairman of the University Grants Commission (2000-2005) and Senior Advisor and Trustee of the Science & Technology Park, Pune University. A Raja Ramanna Fellow, Prof Nigavekar has also been the Founder Director of the National Assessment and Accreditation Council (NAAC).*

The topic for today morning's session is *University Science and Technology*. I call it a perpetual topic because when we were students, we would frequently hear about references being made to university, research, and technology. Later when I changed over to the other side, we continued the same *raga*—university, science, technology. From the teaching position, I went into a slightly higher domain and started deciding upon how things should happen, and still continued the same refrain. Yesterday, while listening to the numerous wonderful lectures, I was wondering, "Where do I fit into this"? I learned how Prof Udgaonkar was trying to do a large number of things through the TIFR, and was also interacting with the Mumbai University. I also heard about how he would often return a sad person after trying to move the Board of Studies or the Academic Council and many other organisations. I think, almost simultaneously,

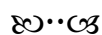
there was a bunch of unfortunate people; I call them unfortunate because they did not belong to what the papers called the *Mandiyali*—TIFR, BARC...the big circles. We were some eight or ten people, one of whom is here today—my colleague, Prof Takwale. We were in Pune struggling to do things in a different way, and Prof M R Bhide, whom many of you may know was the driving force. He had come from Indore and the rest of us came from different places. Prof Takwale had just returned from Russia after doing his PhD in Moscow. We were all struggling to change the system while being within the system—as Anil Sadgopal said yesterday. No doubt we were often disheartened, but we decided to be within the system and start changing it. I may with some modesty say that to a large extent, we succeeded. The Physics Department became the nucleus for change in the Pune University; many new things were begun

and it was reflected at a later time. A series of Vice Chancellors at the Pune University came from a physics background, and it ended with me. Many of my colleagues called me 'the last *malusara*' or the last fort. I was the last person to go and I could not penetrate up to Delhi with no support. Going to Delhi is always a bigger sort of thing.

Now UGC (and Prof Udgaonkar was deeply involved with it) went into a programme called the 'University Leadership Programme'. It was initiated in many subjects including physics, chemistry and mathematics, but physics was the largest number—thirteen. That was an odd number, but Pune had one of them and I was the person, as Prof M R Bhide said, who was to coordinate this. We were struggling for many things; trying to do new things at the undergraduate level, devising experiments, creating equipment in nuclear physics, solid state physics (solid state physics was entirely my responsibility) and so on. We created a set of equipment within Rs 11,000 with a good number of experiments and magnets being given to colleges. We used to put everything in a van and go to various colleges of Pune University. We were also trying to initiate the research component. In the early days when Prof M R Bhide arrived, we were 25 people, and two of us wrote several individual, independent research schemes with different names. Prof Takwale might also remember, a couple of us wrote for everybody because we had no research money. Then, the largest individual fellowship was Rs 15,000. Out of 35 such schemes that were

submitted, 20 were cleared. That was 20 x 15000 =Rs 3 lakh. That was the way we started. Later, we could get a large sum of money. The point I am trying to make is that cultivating the research culture in the university system and taking it to technology, has always been a Herculean task. Some universities have been lucky and some were unable to do it. That is why it was felt that the university system was not responding to the needs and demands that existed as far as research or technology was concerned. The quality of education was also different. We will be talking about that later. So many parallel things happened.

On the whole, if you look at what has happened in last four decades, there certainly has been a positive change which I will be talking about at the end. But to ascertain whether there really has been a change, when I became the chairperson of the UGC, we did a sort of critical analysis of our work which we called 'University Performance Study'. It was put up on UGC's website. Many people may not even have seen it. We created a Performance Radar for every university (Dr Mukunda might have seen that). It is still on the UGC website, but it has been thrown into the 'Archives'. I wish it was always in the front because it has to be a perpetual thing. We created a parameter and plotted for every university, the academic performance, research performance, and governance performance because ultimately, everything is dependent upon governance. That is where we have to constantly look.





# Unemployable engineers



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## **Prof. S. P. Sukhatme**

*Prof. Suhas P. Sukhatme began his education from New Delhi School and Benaras Hindu University. He did his Master's and Doctorate from Massachusetts Institute of Technology, USA. In 1965, he joined the Indian Institute of Technology, Bombay, as Assistant Professor and went on to become its Director in 1995, up to 2000. His main subject was Heat Transfer and Energy. He has contributed significantly to studies in Heat transfer, Thermal Insulation, Condensation of Liquid Metal Vapour and Condensation of Refrigerants—mainly heat transfers during these processes. From the year 2000 to 2005, he was the Chairman of the Atomic Energy Regulatory Board. He has 70 research papers to his credit and has guided 19 students for their PhD degrees. He received the prestigious Shantiswaroop Bhatnagar Award for Science and Technology in 1986. He was also awarded the Padma Shri in the year 2001.*

I will focus on the Technical Education side. I am sure Prof Mukunda will more than make up and focus on the science side. Again, Prof Joshi will probably speak on technical education with which I have been associated for so many years. My focus will be on Higher Technical Education, my views on it, what has happened in the last so many years and so on. By higher technical education, I mean education which leads to Bachelor's degree, Master's degree and the Doctorate degree in Engineering. But first, a little bit of introduction.

We have recently completed 60 years of independence and the newspapers – those of you who have been reading the Times of India or any paper for that matter would have been struck by how optimistic they are in their assessment of the way things are going on. Even the Times of

India, which at times is dogmatic or pessimistic, had a very optimistic view about it this time. There are good reasons I suppose, for being optimistic because we have got one of the fastest growing economies in the world with a 9% growth rate for the last three years. Things are moving. You look around, there are a lot more cars, lot more traffic, lot more people, malls, and so forth. There is reason to be optimistic on such fronts; it is attributed to the fact that since 1991, the government reduced many of the old constraints which were preventing this kind of development, some licensing procedures were removed, tax structures changed, liberalisation took place, and globalisation has occurred. The impact of joining the Information Technology revolution has been there and we have been contributing to it in some way, and so on. And

lately, much to the surprise of people, even the manufacturing sector which was not considered to be in the forefront until a few years ago, has also been contributing to the economy of country and growing at a good rate. It means that those who are in the manufacturing sector have caught on to the idea that unless you have quality, you cannot really compete in a globalised world. These are all good indicators due to which this kind of optimism is seen in the newspapers and magazines. In fact, I was quite struck by an article in the Times of India on August 13<sup>th</sup>; I will just quote a sentence or two from it. It says, "Not only is the nation one of the fastest growing economies of the world, it also boasts of an outstanding Research and Development boom that can match, if not outshine, the best. Technology is fast becoming India's biggest strength and strongest differentiator". The article is on the centre page of the Times of India, and the author lists some of the current ambitious projects which he says are proof of his statement—like the Skybus for transportation; our proposed voyage to the moon, *Chandrayaan*; the first indigenously built aircraft *Saaras*; the Worli-Bandra sea link and so on, have been mentioned as projects of a certain calibre. The article went on to say, "As India commemorates its 60<sup>th</sup> anniversary of independence, it is time to celebrate India's achievements in field of science and technology, earlier assumed as an exclusive bastion of global powers". It is a very strong and positive sentence. Is this euphoria justified? I wish to address that question to you and make certain comments on it. Is this self congratulatory tone justified? Let us examine that in the space of the next twenty minutes.

It is almost axiomatic that achievements in science and technology can occur in a country only if the education in that field is of world-class standards. I do not think anybody will dispute it if I make such a statement. So therefore, if one is to examine whether this euphoria is justified, one needs to examine the present state of higher education in science and technology. As I said, I will be focusing on education in technology.

What is the present state of higher technical education in our country? Is it in good shape? Is it producing creative, innovative engineers? What is the output in terms of numbers? What about the quality? We will examine these issues and I will speak under three headings. First, I will speak about the output in numbers. How many persons are we turning out at different levels? How many at the Bachelor's in Engineering level (B E or BTech)? How many is the nation producing at M E or M Tech level, and how many at the PhD level in Engineering and Technology? The second broad issue I will speak on and spend some time on, is that of quality; numbers are one thing, but quality is quite another issue. Finally, I will speak a little about the reservation policy which many of us are rather excited about; certainly the newspapers are excited about it.

Let us take the first issue. We are concerned with *numbers*. How many engineers or technologists is the nation producing at the three levels that I mentioned? First let us look at the Bachelor's level. I will trace the growth over a period of time. Our benchmark has to be around the year 1950, that is, around independence and we need to come till today. I will give approximate numbers.

- In 1951, the start of the 1<sup>st</sup> Five Year Plan, the nation produced approximately 5000 engineers a year and we had about 50 technical institutions. The numbers grew slowly at first.
- In 1961 the sanctioned capacity was around 15,000
- In 1971 the sanctioned capacity was around 18,000 and
- In 1981 the sanctioned capacity was around 35,000.

These are rough numbers which I have taken from the UGC and AICTE reports. The output roughly matched these numbers. Because there was a tremendous shortage of seats, all seats used to be filled up in every college. Mostly, they were Government colleges; at that time there were very few private colleges. So the output roughly

matched the sanctioned strength. When I say that 35000 seats were there in 1981, it means the nation was graduating about 90% at that output. If it was 1981, and you want the output for that year, then you have to go back to the sanctioned strength four years earlier. So let us say, in 1981 it was about 30,000.

In the early eighties, something very interesting happened. Private colleges were permitted to be opened. Maharashtra was one of the states taking a lead in this matter along with Karnataka, Andhra Pradesh, and Tamil Nadu. Since then, the growth rate in sanctioned capacity (strength) has been explosive or spectacular. In 1991, we had doubled the sanctioned capacity to about 70,000. In 1996 we crossed 1 lakh. (Now, I am not taking a 10 year level as I was earlier). In 2001, it was 135,000 and in 2007, it has just crossed 5 lakh! That is the present sanctioned capacity in the country. The total number of institutions giving degrees in the country is around 1500. That is the growth. So that is why I said explosive, spectacular; you can use any adjective you like.

Of course, output will take some time to grow and not all seats are being filled because now we have an overkill, so to speak. The statistics for the current year or even for the year 2006 are not reliably available, but the best estimate for this year (2007) is that around 250,000 people got their Bachelor's degree in Engineering. Now, the way this is estimated is as follows: first of all, the sanctioned capacity today is 5 lakh. Sanctioned capacity four years earlier was about 4 lakh and it is roughly estimated that about 60% to 70% of this is the output. Earlier, the output was 90% to 95% of the sanctioned capacity. Today it is around 60% to 70%. Quite a few private colleges in surrounding areas and small towns do not fill their capacities fully. So, the estimate is that in 2007, the number of students who have passed out with a Bachelor's degree is probably about 250,000. It is not just my estimate, but also from one other report which was recently done at IIT Bombay. When I say that sanctioned strength has grown, it has grown not only in traditional disciplines

but also because new fields have been introduced—at first it was Computer Science and Engineering, and now it has been Information Technology. These are two fields in which everybody wants to start Bachelor's degree programmes.

Now, a few remarks: (1) if you go back to the year 1971, the output of engineering was around 18,000. The five IITs then contributed approximately 2000 out of those 18,000 or 9% to 10% of the Bachelor's degree output of the country. Today, the output of the seven IITs is approximately 3000, but the national output is 250,000; so IIT's contribution to the national output is just a little over 1.5%. Keep that in mind because many a time, there are statements made like, "We should do this in the IITs; if the IITs do it, the nation has done it". Nothing of that kind happens because IIT's contribution to the total picture in terms of numbers is exceedingly small. Keep that in mind. (2) If you look at the output which is say 230,000 per year today, and you ask what the output is per million of population; it comes to a little over 200. This is a number which many developed countries have—200 per million of the population for Bachelor's degree. The USA has a number like 240 and some countries have 300 per million. But all the countries have numbers in the range of 150 to 200, or 250 to 300. So in terms of numbers, you have reached there. I am coming to other aspects later. Right now, I am talking only about the numbers.

Now, what about the next level of degree, the Master's degree? I go back again to year 1950, and if you ask yourself what was the output then? We had just a handful of institutions giving either Master's degree, or in those times institutes like the Indian Institute of Science gave Postgraduate Diplomas in Engineering. Let's say that it is the equivalent of a Master's degree. The national output in 1950 was probably 100 to 150 Master's degrees for the whole country—the institutions being IISc, B E College, Roorkee which had just started a postgraduate programme, and a few other colleges and institutions. The output was about 100 to 150.

In the year 2000, when the Rama Rao Committee submitted its report on postgraduate studies to the AICTE, the estimated number of seats sanctioned for a Master's programme in the general category was around 11,000, and in the reserved or sponsored category was another 7000 to 8000. In year 2000, an overall estimate was made based on the measurements of certain selected colleges. The committee estimated that the total output of the country was between 6000 and 7000. Again, I do not have number for the year 2006. AICTE also does not have the number. If you ask them, they will tell you the sanctioned capacity for the country today is 13,000. However, it will take about four or five years before we know what the output in 2006 was. Our best estimate is that the output today is probably about 15,000; and again, there are ways of making such an estimate. For example, at the IITs and the IISc, approximately 90% of the sanctioned capacity is an output. One knows that in some other well known institutions, the output is around 70%, and one knows that in many other institutions where the sanctioned capacity is there, the output is barely 50% of the sanctioned capacity. Using these, and giving weightage to the sanctioned capacity of these three types of institutions, one can get the estimated number. I will not be too wrong if I say that today, the output is about 15,000.

Now, given the size of our country—we are talking of 1000 million people—and the size of our Bachelor's degree programme, the Master's degree output is really low. Again, if you consider some other country like USA for example, normally, approximately 20% to 25% of those who do a Bachelor's degree will go on to do a Master's degree. I am talking of USA, Germany and countries like that. However for us today, even if I use a number of 15,000, it still comes barely to about 8% of the Bachelor output. So at the Master's degree, the output is well below what it should be or might be if we should project as we go along.

Next, I come to the third level, the highest level, and that is the Doctoral level. At the PhD

level, I do not think anybody disputes the need that a nation needs PhDs in Engineering. You need quality man power at the PhD level for doing R&D. You need quality man power for teaching and research. No question about it. In 1950, the output of PhD in Engineering and Technology was nil; in the year 2000, adding up data from all the institutions, the Rama Rao Committee estimated it around 500. Today, the best estimate is between 800 and 900. Only 900 people with a PhD degree in Engineering and Technology in a country of our size! What we are saying in effect is that, if you look again at the Bachelor's degree output which is 250,000, less than 0.5% of the Bachelor's degree output is finally going on for a PhD. I have not even come to the issue of quality yet, I am just talking of numbers. And out of this 900 again, as a matter of interest you would like to know, about 2/3<sup>rd</sup> of them come from the seven IITs and the Indian Institute of Science. They contribute to approximately 2/3<sup>rd</sup> of the output of 800 or 900 PhDs in Engineering and Technology. That is the position for the whole country today.

So if you look at numbers, we have a spectacular growth at the Bachelor's degree level; then some growth at the Master's degree level, but certainly not what we probably need; and our growth at the PhD level has to be a whole lot more if we really want to think of ourselves as a nation having the manpower needed for doing R & D of a certain type. So, this is the position as far as numbers are concerned.

Now I come to the second aspect—the *issue of quality*. Measuring quality is not easy and one can in general terms say that the quality is poor. Each person, when he uses the word quality, means different things. The word itself means different things to different people. What do we mean by quality in engineering education? Let me show different ways of looking of it. When some people say that 'the education is of quality' (let us focus only on the Bachelor's degree), or that 'he has got a quality education', what he means is: the person who has the Bachelor's degree has a good general knowledge in his

subject, he knows how to apply formulae for common situations, he is aware of some of the latest technologies in his particular discipline be it Mechanical, Electrical etc. Then we say he has had a good education, he is aware, he knows how to apply, knows how to use a handbook, and knows the codes and standards. To them, that is adequate in terms of quality. That is perfectly justified for the kind of job he will do, and that type of education for that person is adequate.

To some, quality has a more general meaning. Quality means that the engineer who passes out must be able to analyse new situations, he must be able to synthesise for new situations, he must be able to innovate and design new products or processes. Common sense, anyone can pickup; handbook, codes, and standards, anyone can do it. So, quality to such people means *raising the bench mark* so to speak. Therefore as I said, quality means different things to different people. I submit to all of you today, that even with the lowest benchmark that one may set for quality, the technical education system today is in dismal shape. We need to do a whole lot more if we really are to move on and take our rightful place in the committee of developed nations.

Barring a few institutions like the IITs, UICT, or a few NITs or B E College—where to some extent something good is happening or where there is a reasonable Bachelor's degree programme—250,000 may be our output today, but it *effectively* is what I call, a vast barren land. Almost three out of four Bachelor's degree holders who pass out every year are in the opinion of most people who employ them, *unemployable*; even with, as I said, the lowered benchmark that we are applying. This is not a good situation. Hundreds of institutions, private and public have poor infrastructure, poor equipment, and inadequate equipment. Now what can we do or what shall we do? The Government is one stakeholder in this. Obviously, it is trying to do something and some good things are happening. For instance, the NITs have been created. It is not just a matter of

injecting more funds. The NITs' governance structures have been changed so that they will have more autonomy, and they have been given the 'deemed university' status and so on. And I think to some extent, some impact is there. The government has put in more money by creating more, new IITs; Roorkee has been made an IIT and so on. Some private institutions like the Vellore Institute of Technology and The Amrita University are trying to put in money for education. So, some efforts are being taken. But when you look at the level of efforts needed and the massiveness of the problem, the current efforts seem miniscule in nature. To my mind, if there is one issue which holds the key to the quality of our technical education system, it is the strength and quality of the faculty who teach at these institutions. To me, that is the biggest issue. You can put in funds, you can have more buildings, you may make systems more autonomous and so on, but the primary issue remains the strength—the number of people teaching and the quality of those people. That to me seems to be the key issue; the human resource which builds up other human resources.

It is not easy to persuade young and able persons to join the teaching profession today. Salary scales are not attractive and the need for a postgraduate degree to be eligible for a promotion is not easily satisfied. So these are some constraints. We need to do a lot if we really want to move up in this respect. What are some of the measures? Well, it is not one thing but many things that are needed. You need for instance, to have a massive programme for training young people equivalent to what was the TTD programme in the '60s. In this programme, many young people were encouraged to join, taken as lecturers but made to do MTech as lecturers, and then recruited back. So once they are in the system, they get interested enough to stay on. Many of our present professors went through the TTD system in the late '50s and the early '60s. We could, for instance, jack up the input in the quality improvement programme. That has stayed sort of stationary.

Not only is it a question of attracting new faculty, you also need to create conditions where new faculty will want to stay on. That means you have to offer them incentives including monetary incentives to do quality work. You can reward people in so many ways. A faculty member publishes a good paper in a well acclaimed journal; what is wrong in paying him a little more for that? He gets a patent; you pay him for that. So many countries are doing it. China is an example. But set some benchmark and set certain transparent procedures; if you publish in a standard journal, you will get that much honorarium and so on. You could have more 'Excellence in Teaching' awards. I consider that a good way of rewarding good teaching. Every institution must have those and must reward the best teacher every year so that they are known and receive some monetary benefit from it. You should encourage people to do consultancy in engineering – a good way to earn money. So, there is no question in my mind that it is not just one thing that needs to be done, but many things that need to be done if we want to encourage good faculty to come in.

Quality can be improved by improving linkages with industry; that is important for any technical institution. You could have adjunct faculty from the industry. We have not done enough of that in most colleges, including the IITs. We need to have a lot more adjunct faculty. Though many people in the academia feel that they are two different worlds, in technical education, industry and academia ought to be together so that there is an interaction going on all the time. It is not that you agree with everything that industry says or they agree with everything that you say. But you need to keep talking to each other, at least in technical education. These are some of the measures which certainly need to be undertaken if we wish to reach anywhere in this business of improving quality.

Finally, I will speak briefly about the *reservation policy* which is very much in the news nowadays. It is in the news because it is proposed

now to introduce reservation for the OBCs (Other Backward Classes). Reservation is not anything new. Reservation for the Scheduled Castes and Scheduled Tribes has existed in most educational institutions. At the IITs for instance, it has existed for more than 20 years now, being 15% for SCs and 7.5% for STs. In the joint entrance examination, there is a separate merit list according to which they are admitted to the institutions. There is a slightly lowered cut-off mark for these people and if they do not come up to the lowered cut-off mark, they have to do a one-year refresher course in an IIT and pass in it. In this refresher course, they do more of Physics, Chemistry, Mathematics, and English after which they are taken in the first year. That is the way it is being handled.

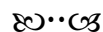
Something similar is proposed for OBCs. A 27% reservation has been proposed, and since there was considerable hue and cry that the general seats would be reduced, the government said, "Well do not reduce the general category seats, just expand the input to these institutions". When you say 'expand', immediately, issues like infrastructure, availability of classrooms, availability of labs etc come in; and therefore, a via media suggestion was to do it in a phased manner. Instead of doing 27%, do it in 9% per year. Now, the matter has gone to court, and because it could not be done this year, it will probably happen from the next year. Other issues like, whether every one should get reservation or only those who are not economically well-off should get such benefits; that matter is also in the court. These things will get sorted out. But the point is, reservation is here to stay. There is no point in anyone saying that it should not be there or it should be there. It is a part of the business of a nation growing up.

I personally look upon it as a challenge which every institution has to take up rather than saying, "should we or should we not have reservation"? It is a challenge, it is a duty, it has to be done, and it has to be done well. That is the way I look at it. Whether it is introduced in a phased manner, whether it is given to the creamy

layer or not, is for the courts to decide. Once you have a set of students, and believe me, all the students who come for engineering, if you motivate them there is a lot you can do with them. There is nothing like saying that they won't be up to the mark and so on. Yes, you may have to work a little more with them. With OBCs, in fact, you will have to work little less than with SCs and STs because in general, in terms of educational attainment, the OBCs are better off and every one knows that. In fact, the problem will not be that severe with OBCs. So, it is important that the matter gets thrashed out rather than go round and round in so much discussion. Let it get started. However, what is important—and people often do not recognise it—is that when we introduce a policy, we should also give thought to the time it is going to take to adjust. Suppose for instance, one says one needs a whole generation to implement a reservation policy, let us say for OBCs. I see nothing wrong in that. One generation means 20 years; all right, for 20 years (take 3 years to phase in) you have 27% reservation. But right now, you should also have a policy for phasing out. Phasing out again cannot be a step jump. With a step jump there is always a resistance to any change; it has to be a gradual phasing out. It should be planned such that over one generation, you have 27%. After one generation reservation will be dropped from 27% to 26% to 25% to 24% that is, 1% per year. Let it take 27 years to be phased out. But let us agree on that. Then there will be no opposition.

In fact, it will be smoothly phased in, stay constant and gradually be phased out. Even if you take two generations, something good will come out of it eventually. I have no doubt about it.

So, let me sum up now. I basically spent my time talking about the output we are getting through the three levels of our education, the Bachelor's degree, the Master's degree and the Doctoral level. The point I made was, at the Bachelor's degree level the output is probably satisfactory in terms of numbers; at the Master's degree and Doctoral level, even in terms of numbers, we are far short of where we ought to be. Then I spoke of quality; in terms of quality, we are nowhere – whether you talk about Bachelor's degree education, or Master's degree education or the Doctorate degree. The situation really is poor all across the country, barring a few select institutions which contribute a few percent to the overall national scene. We need to do a whole lot more in terms of money, infrastructure and faculty; which means a national effort and a national determination to do something. Unless we do that, all this euphoria about which I mentioned at the start does not make sense. People may talk, but it is not really a justified euphoria for a nation in terms of being at the top level in science and technology. The newspapers may say what they like, but the ground reality is very far from that. It can happen only if we raise our quality; and at the post graduate level, also quantity.



## ICT - A green pasture



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### **Prof. J. B. Joshi**

*Born in 1949, Prof. J. B. Joshi represents the post independence generation. He had his education – Bachelor's, Master's and Doctorate degrees from Mumbai University. He joined the University Institute of Chemical Technology (UICT), Mumbai in 1972, became Professor in 1986 and Director in 1999. His fields of specialisation include Fluid Mechanics, Computational Fluid Dynamics, Designs of Multiphase Reactors, and Computer Aided Processes among others. Prof Joshi has guided 50 students for their PhD degree and 51 students for Master's degree. His experience in Computational Fluid Dynamics and Design of Multiphase Reactors has also been used in the industry. He has been Consultant for many large, medium and small scale chemical process industries. Prof Joshi is a member of the Atomic Energy Regulatory Board. He is also the recipient of the prestigious Shantiswaroop Bhatnagar Prize for Engineering Sciences (1991) in addition to several other awards*

I will be speaking on technology education in universities, and in place of 'challenges', I will say, 'opportunities'. So, the title of my lecture is *Opportunities in Science and Technology Education at the University Level*. I come from the University Institute of Chemical Technology where undergraduate and postgraduate programmes are taught together, similar to the IITs and NITs. One of the features or the advantages of having coherent undergraduate and postgraduate programmes is that when research is the main competent, the teacher remains at the frontier of knowledge with the research base. The teacher can effectively expose the students to new knowledge and can apply it to the industry. The knowledge base in the industry may often be at the textbook level. A teacher can create in the

students, inquisitiveness, an interest in research, the ability for originality and innovation, and develop new experiments for the undergraduate laboratory. There is a possibility of intermingling of undergraduate and research students, which is an advantageous feature for exposing them to the process of knowledge generation. The result is a balanced education; if the two are together, the undergraduates and postgraduates get equipped with fundamental knowledge, an analytical mind, innovativeness and confidence. For postgraduate programmes, there is a possibility of developing the ability to identify the problems of our own society and industry, find solutions for them, and implement the solutions. I am going to elaborate on this presently.



Research and undergraduate education, and the university-industry partnership, which Prof Sukhatme mentioned, are important aspects. Success is based on several components. According to me, the most important component is mutual trust and respect. And that happens when the faculty from the university understands the value of money—not of new knowledge, which indeed, should be valued by the industry—the value of time, and the value of *words* either spoken or written. Suppose I want to claim that I have a new design which can produce 10 tonnes per day; it should really produce 12 or 15 tonnes per day rather than 8 tonnes per day. That is what I mean by ‘value of words.’ On the other hand, generation of knowledge is done by highly committed and motivated faculty and students. This should be recognised by the industry. Consequently, a mutual respect and trust will develop, and there will be a very long and stable relationship.

I come from the Chemical Engineering and Technology discipline. The overall worldwide turnover of the chemical industry sector is Rs 65 lakh crores, in which India’s turnover is only Rs 1 lakh crore, about 1.5%. Then take any sector, say the nutraceutical and functional food sector or the herbal healthcare sector; while the global turnover is Rs 11 lakh 20 thousand crores, the turnover from India is just Rs 9000 crores. We know that *Ayurveda* originated in India, but what we sell in the worldwide market are leaves, roots, stems and not value added products. We get only Rs 9000 crores whereas the market is more than 100 times this amount. When I shared this information with Dr Anil Kakodkar last week, he told me a similar story for Titanium. We sell gravel, whereas Titanium costs Rs 2000 per kg. So, though the value addition is more than 100 times, we do not make any Titanium in the country. In the case of biotechnology, our contribution is again, less than 2% (Rs. 3000 crores out of the world’s Rs. 2 lac crores). In the case of energy, we produce only 0.37 terawatts out of the 13.7 terawatts produced in world. The principal reason for our

very minor contribution is our cost of production which is 20% to 50% higher than the global average. And the principal reason for this higher cost of production is that we do not generate our own knowledge for our industries and society.

We got our independence in 1947 and we are celebrating the diamond jubilee year. Yet, 90% of the knowledge is still imported for various industries including petrochemicals, refineries, healthcare and agrochemicals. However, this problem can be overcome. Let me take the case of India becoming competitive in the industrial or manufacturing sector. I will explain this by taking a few examples. There is a very small sector where we implement our own designs and processes, and that is in *Principal Design*. In the ‘90s, there was a need for a catalytic hydrogenation process for certain products in the healthcare or pharmaceutical and in the perfume industries. We are familiar with the household mixer of 1 litre capacity. Let us imagine this mixer to be of 2000 litre capacity. Hydrogen gas is passed inside and the unreacted hydrogen goes up into the gas space. Now, Hydrogen being expensive (Rs 35 per cubic metre) has to be recycled for complete utilisation. Our industry wanted to start this business and one company from Switzerland was selling this equipment. A company here asked me if I could help them by going to Switzerland and seeing how much we could get it for. The Swiss company had quoted Rs 10 crores (at that time, rate of exchange was \$1 crore for the 2 tonne equipment). But because fabrication is cheap in India, our industrialists requested me to ask them whether they could provide us the drawings so that we could fabricate the equipment in India, and on the whole it would be cheaper. The company readily agreed and said the drawings would cost Rs 9.5 crores, and you say whatever you want in Rs 50 lakh.

That was the starting point for our Institute to develop this equipment. We started work on it in the late ‘80s, and in 1992, we installed a 4 m<sup>3</sup> equipment that was twice the size, in Rs 30

lakh only. Mr Deodhar will agree with me that this is the story in all the sectors. Later, we installed many more, and recently, the 75<sup>th</sup> equipment has been installed. No equipment has been imported. The same company which was selling at \$ 1 crore has brought down its price to \$ 2 lakh but nobody is buying it. What I am trying to communicate is: why are we not internationally competitive? If our manufacturing is based on our own knowledge, then it can become competitive. How was the designing of the equipment done?

Safe equipment to internally recycle Hydrogen gas can be designed by understanding the fluid mechanics involved. This is done by analysing with computational fluid dynamics and experimental fluid dynamics, identifying the low pressure regions, and optimising it with respect to energy and connectivity between the gas space and those points. I have fifty such stories. I would like to reiterate that we can do it ourselves; we must generate our own knowledge for our society for becoming internationally competitive.

Next, the available flotation machine equipment in the Metallurgy sector uses the self-inducing principal. However, for one kilowatt energy, it gives only 1 litre per second whereas, 50 litres per second are required for catalytic hydrogenation. So, a fifty-fold improvement is required, which is done by properly understanding the fluid mechanics. In the final equipment, the topmost impellor is the self-inducing impellor, the second impellor disperses the gas throughout the equipment, and the third impellor does the job of catalyst suspension. The three impellors put together are as efficient as, or more efficient than what is internationally available. Prior to this equipment, hydrogenation was being done chemically, which was polluting the atmosphere. Now, it is being done by catalytic hydrogenation. 50,000 tonnes per year of hydrogenation is happening in India using this technology. There many other similar stories. For example, technologies have been developed in our own country as alternatives to international

technologies by ICI and DuPont. monomer of polyester, and moving bed reactors for polyester manufacturing are shown as examples of the ways in which our country can be economical in the international market.]

If you consider the Biotechnology sector, a lot of research has been done at the universities and research institutes in our country. At the laboratory level, we have made many interesting molecules but on the scale of milligrams or a few grams only. However, we need to make several tonnes per day. We need knowledge generation in that particular sector to scale it up to industrial quantities. How do we incorporate innovation so that in micro-design, several tonnes can be produced economically? It can be done and I have a few stories in the biotechnology sector. I will not go into the details as I have already communicated the message.

In the Food Technology and Engineering sector, we process only 2% while 12 % is wasted. We can make many valuable products from the 'to be wasted grains or food products'. There are a large number of opportunities in the area of food processing. I have shown 20 possible PhD programmes that focus on every aspect of the design of processing. The plants and machinery for making Indian sweets and savories, solar refrigeration, and other ideas are there. The last one is the 'Energy-efficient Processing and Equipment for Concentration, Hydrolysis and Cooking'. This equipment has been developed and deployed at more than 100 locations, and three months hence, 100 more locations will see this equipment.

Now, how many opportunities are available? We are participating in only 1% of the world market. If we understand the needs of our society, we can crisply find out how many problems are there, divide them into research projects, get them executed, and get the answers in a way that can be implemented. What we will achieve in this endeavor is: if the solution has to have longevity and be economical, then we have to revert to the fundamental sciences. That is most important. Secondly, while developing

commercial equipment, the engineering and applied sciences come into the picture. During implementation, many personnel are involved and this stage also affords an excellent education.

Let me tell you some energy facts. The total energy consumption in India is 2 billion barrels of oil equivalent per year, which is 300 million tonnes per year; and energy consumption in the form of liquid fuel is 150 million tonnes per year. Now how do we solve this particular problem? All of us now know the energy requirement of the country. These days, we talk about bio-energy. The country produces 3000 million tonnes of waste, equivalent to 300 million tonnes per year of liquid fuels – twice our requirement. If you try to do it directly from biomass; at present, 10 tonnes of dry biomass per hectare is produced, and we can get 500 litres of ethanol per tonne of biomass. Now, if you want to satisfy the requirements of our country, 60 million hectares out of the 300 million hectares of our country need to be used for the purpose of fuel. If our energy consumption is going to be like China's, then 180 million hectares will be needed, and if the consumption is going to be like USA's, then 1600 million hectares will be needed. We will need five times our land to reach the energy generation and usage of the United States!

Suppose the following research problem has to be taken up: the growth rate of biomass has to be increased from 10 tonnes to 20 tonnes, and from 1 tonne of biomass, we should be able to produce 1000 litres of alcohol so that the land requirement goes down to 15 million hectares. The numbers I have given are doable, nothing beyond the scope. For this, we need to do the following: generate novel and sustainable technology for fractionation of ligno-cellulose and subsequent bioconversion, develop crop varieties available for bioconversion, use cost effective enzymes and microorganisms for breakdown of ligno-cellulose, and develop biotechnologies for conversion of sugars to alcohol and for purification of products. This

means we have 30 PhD programmes here to be executed by institutes, and when these become successful, we can achieve our objectives.

Additionally, if we can generate hydrogen at a certain capacity and combine it with bio-energy, the land requirement reduces from 15 million hectares to 5 million hectares. The cost of electricity (mainly from coal, nuclear, gas, oil, wind, and solar sources) is 22 cents; it is 22 cents mainly because the investment is Rs 12 crores per megawatt. Earlier, it used to be Rs 100 crores, however, a lot of research has gone in and now it is Rs 12 crores per megawatt. More is being done all over the world, including at my institution, to bring the investment down to Rs 6 crores per megawatt. (I am happy to inform that my collaborator Prof Panse is here in the audience).

Again, there is a possibility of 20 PhD programmes in the use of solar energy for the post-harvesting and refrigeration processes. Another possibility lies in the process of conversion of natural gas to liquid fuel. How many opportunities are available? How much can be done? In the case of atomic energy, the Director of the Indira Gandhi Centre for Atomic Research (IGCAR) and I met recently, and together, we brought out 24 likely projects and 52 PhD programmes for developing new processes for fuel recycling, as well as for bringing down the capital costs for fast breeder reactors; same in the case of wind energy.

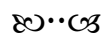
What are the core values? While we are doing this, a very fine balance is maintained between basic and engineering sciences, technology development, and implementation. Balanced training is imparted to the students to ensure quality research, as Prof Sukhatme said, by publishing in high citation impact journals. My institution contributes 169 citations per faculty member which is comparable to the best in the world. Generation of external revenue to the block grant which is received from the Government is four fold. Average consultation income generated is Rs 1.2 million per faculty member per year. Out of this, a third goes to

institution, and salary for faculty is less than that one-third. How much value can be generated? How do the advanced countries plan their science education and technical education? In the mid '60s, Japan started their programme in science and technology. [Graph shown here] The number of PhDs in engineering per million of population multiplied by 1000 is the per capita income of the country. So in Japan, the per capita income is 33,000 (33 PhDs per million x 1000). In USA, it is 31 PhDs; therefore, their per capita income is 31,000. The next four are European countries, and as you can see, our country is at the bottom in terms of numbers of PhDs and consequently in per capita income—this was the situation in 1999. Coincidentally, our population is 1000 million, so we need not calculate the number per million and multiply by 1000; the number of PhDs is itself the per capita income. In 1999, we were producing 470 PhDs, all institutions and all branches put together, and our per capita income was 470. In 2002, we had 650 PhDs and the per capita income was \$650. Today, it is 1000 PhDs and our per capita income

is \$1000. So generating our own knowledge is extremely important and we have to go up to at least \$ 3000 if not more.

Coming to the conclusion, university science and technology education provides more than enough opportunities and we can create a “win-win-win” situation. I say “win-win-win” situation because students receive a balanced education, the money required by institutions for research can be obtained, whatever money is given to the students, teachers and institutions is only 1% of the industry’s benefit, and hence the industry gets a 100 fold benefit. If that happens, then there are more job opportunities, a lot of energy conservation occurs, there are benefits to the environment, the economy of the industry and that of the country improves. We get a manifold winning situation. Higher education is one of the major factors that can bring about real independence to our country because the ongoing millennium is going to be a knowledge driven one.

The point I am communicating is: *we can do it and let us do it.*



## *China is changing - What about India?*



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### **Mr. P. S. Deodhar**

*Mr. P. S. Deodhar was obtained his B.E degree in Telecommunications from the University of Pune in 1956. Between 1956 and 1962, he was involved in research and development at the Tata Institute for Fundamental Research (TIFR) and at the Indian Council of Medical Research (ICMR). Mr Deodhar founded the APLAB Industries which manufactured instruments and started R & D activities for the same in 1963 and '64. He was Chairman of the Electronics Commission from 1986 to 1991 where he held the rank of Minister of State. Between 1988 and 1990, he was Advisor (Electronics) to the Prime Minister. Mr Deodhar was Chairman of the Broadcast Council, Govt of India (GOI); Chairman, ET&T a GOI Enterprise; Chairman, Meltron Limited, Govt of Maharashtra; and Chairman, Mahanagar Gas Limited which was a joint venture with British Gas. As far as ET&T and Meltron are concerned, he has successfully brought them out from a loss to a profitable situation.*

Mr Deodhar has been involved in many other activities. He was Chairman of the World Marathi Conference held in 1997 at Jerusalem, Israel. He was Chairman of the World Marathi Academy, and since 1999, he has been the President of the Marathi Vidnyan Parishad.

It is a pleasure to be addressing an audience of such eminent people and the subject is 'University Education'. I was lucky because just before me, Prof S P Sukhatme and Prof J B Joshi have laid a very strong foundation of what the status of education is and that makes my life easier. Another difference is that they are the manufacturers; they produce students, graduates, postgraduates and doctorates. And in my work, I use those products. So, as a user of

products developed and created by Indian universities, I think Dr Sukhatme has rightly said that there is much to be desired.

Why we need a university education? Why do we need university graduates? Why do we need technical education? We need technical education basically to produce products; products which will add comfort to society, which will improve efficiency, personal efficiency, organisational efficiency and national efficiency. So it is a product driven demand for man power which will give this product to the world. I do not want to go into the past because it is gone; whatever errors might have been done, they are over. We can only look at what is ahead of us and what is happening today. Is it relevant? Is it right? And

my concern today is that India produces less and less products. We have less and less engineering in the real terms. So while our production of engineering graduates is increasing, their utilisation by the industries in real production is simply not there.

Just to give you an example, in the last 14 years in India, the total employment in the manufacturing process industry has declined. Most of what we term manufactured output of India constitutes re-labeled products. Fifteen years ago, Godrej had almost 100% production produced in their plant whereas today it is less than 25%. What concerns me is that we are not aware of what is happening. In the same period of 14 years, China created 7.6 crores of manufacturing jobs. We should be worried about global competition, and our competition is right across the Himalayas. What is happening in China? What is difference between what is happening in China and here in science, technology and research? Let us take all the three aspects.

If I look at what is happening on the manufacturing side, there is a distinct difference between manufacturing in India and manufacturing in China. Since independence, and very rightly so, we protected Indian industry; we banned imports and put heavy tariffs. These were steps which were necessary for a young nation and indeed, manufacturing in India grew. But the game of protection went beyond control. Both, public sector and private sector companies in India with the connivance of the bosses in Delhi managed to protect themselves against competition of any kind. Consequently, by the time we reached the mid '80s we had the poorest quality of every product that we produced in India. The customer did not exist in this country and industry was protected for its own sake. So, the first casualty of this continued protection was decline in quality—our sense of quality and our need for quality. There was nobody driving us for producing good quality; the market was accepting and there was no choice but to accept

what we produced. Therefore, our engineers who got into manufacturing got used to this poor quality. In my own company, I had to struggle and take to export in the early '70s just to ensure that we too did not fall into the same slot. But look at China. What happened in China? China had nothing. Between 1980 and 1984, I used to export 10,000 oscilloscopes to China. Today, I import oscilloscopes from China, private label and sell them in India because I cannot match their cost. So I have to import to beat the competition. Why do I have to import from China, and why cannot I manufacture that product? Because I do not get the kind of manpower that is required to produce this class of products, nor do I have the infrastructure provided by the government (which is beyond my control) which is of any class and which will enable me to compete.

What happened in China after that? Things started changing through 1983, 84, 85. China opened their doors and basically sold almost nothing within the country. Everything that China produced for the first 7/8/9 years were products for the western world, with western designs, with western technology, with western machines and a market that demanded quality. So, the entire manufacturing infrastructure of China knows only one way of producing products, and that is, of high quality which are accepted by the western consumer countries. So, there is a great difference between the quality perception of an Indian manufacturing company and a Chinese one. If we have to compete with China, we have to change our manufacturing. The Government is doing nothing about it because our statistics are very confusing. Our manufacturing industries grow at 12%. Essentially, it means that the sale of manufacturing companies grows by 12%. It does not mean that the value addition grew; the value addition has indeed, declined. The honourable few exceptions are the chemical and pharmaceutical industries and a few other sectors where India is doing exceedingly well. So, where do we need our engineers? Who uses our

engineers who are given a degree in engineering but who are not real engineers, if they are unemployable? They ought to be somewhere, but where do they work?

IT or Information Technology is a big consumer of all these mediocre people because IT can do with mediocre people—the kind of jobs that we do for a foreign company. What is the glory in the so called IT industry? For that matter, what *is* an industry after all? In fact, I refuse to call the IT industry, an industry. I say it is an IT business. It is a business of selling manpower or man hours. None of IT companies in our country has a product, not a single world class product exists in India either in IT or for that matter, in any engineering field with a few exceptions such as in the pharmaceutical and chemical industries. But essentially, if you look at the number of patents that we take, or any kind of measure or benchmark that we use to try to gauge India vis-à-vis the world...!

Let us take Information Technology. Recently, I wrote an article in our Marathi Vidnyan Parishad Patrika, comparing *Surnet* which is China's equivalent of our *Ernet*. Ernet started in 1985 as part of a UNDP programme in India and it grew into nothing. It really did nothing for the purpose for which it was set up. What happened in China? I will give you some figures. Surnet today, is used by 2614 universities, 10 provinces and 162 cities in China. It is used by universities, colleges, high schools and middle schools, and 240 million users are linked on Surnet. I have no figures for Ernet. And what are they disseminating? You see, we underestimate China and we are ignoring what is happening there; and from them, learn what we need to do.

On engineering education, we had Prof Sukhatme and Prof Joshi, our two great and honourable exceptions in education in India. I would say as a user, that of the two institutions, the University Department of Chemical Technology as it was called, are doing the right kind of engineering education. We from the industry look up not to IIT I am

afraid. Even if we look at Indian technology generation, how many institutions or universities are contributing? How much co-operation do you see between universities and the industry? I remember, before you [Prof Sukhatme] became the Director of IIT, I had three engineers working in the company, developing products. They were working on artificial kidney machine development. We were working on three or four prime products which involved besides electronics, some knowledge of other processes or technologies. I had approached IIT and asked whether these three people who were developing products could also get their PhDs. That was one way I could hold on to such bright people. I asked if they could advance their academic qualification as well. But it was not possible. There was no provision whereby I could work with IIT; the three boys had to do some work at IIT to qualify for that.

So, there are deficiencies all over. I have no argument about making education an industry. All over the world, to an extent, it is an industry. But is that industry producing any kind of product and are they quality conscious? That is my problem. My problem as a user is that the few engineers that we need are not available. The damage that IT has done to India in terms of manpower is that it has sucked away all talented available manpower, so the rest of the sectors do not have it. Consider a graduate who completes his MBBS degree; what can he look forward to today after spending so much? You know how much money one needs to be a medical doctor. What is his earning if he chooses to do any kind of job rather than practice? I think he cannot get even a part of the salary that is earned by a call center girl. In such a situation, in what fashion will even the brightest of the bright students look at education in India? So, my concerns are in this area.

I recall, in the year 1986 in Delhi, it was proposed that we rename the Ministry of Education as the Department of Human Resource Development. I was with Rajiv Gandhi

when this discussion was going on and I said, “Changing the label may not change the contents of the bottle”—and it hasn’t! This is the same situation with IT. We have IT education, but what is it doing? We proudly proclaim that, “We have such a huge young population in India; 40% Indians are below the age of 25. It is a great asset”. Is it? Our Human Resources Development is the biggest challenge. The way we are educating today or the way we are **not** educating today is going to prove a great challenge for the next few generations. It is not going to be an easy task to contain this ‘below 25’ age group people. Only 5% of them get a chance to get educated today. And getting a university degree is not education. Intelligence, fortunately, is not dependent on the government, schools and colleges. It is intrinsic. It is biological. It is a question of how will you reform and utilise that intelligence, polish it, give it a shape, and give it a direction. Is that happening? That is my concern. I am concerned because it is a globalised world and we have to make a mark in this globalised world—not just become sub contractors of developed nations, which is what we have become. I think there is a significant need to do that. I remember in 1987, things in Delhi had become pretty distasteful for me because I went there with great hopes thinking that a few things could be changed. However, I realised that in Delhi, everybody knew exactly what needed to be done but they did not want to do it. There were very few who, I could say, were interested in nation building as such. And out of that frustration I started writing poetry. So I will read out one poem.

*What is the use of any data to me  
if it can't collate into some information?  
And is information any good  
if it adds not to my knowledge base?  
And is my knowledge of any consequence  
if it overwhelms and clouds the wisdom within?  
or doesn't need to any fruitful action?  
Tears tell yet fast in pages of the rock  
Where is the life we have lost in living?  
Let's wait and think, allow the idea to sink.  
Our rural folk's life and its culture is almost immortal  
having far outlived our urban craze.  
The kingdoms and empires, invaders and what not.  
Of what use then is the Infotech  
if it can't make me a better farmer, or a better weaver,  
or a skilled carpenter in my own environment?  
Many talk today of education technology...  
We the city breeds enthusiastic and earnest  
are at it with missionary zeal and zest.  
But if this new tech fails to enrich  
the lives of our rural folk and enhance their work and  
art,  
or if it just grooms the keyboard babus out of our rural  
lads,  
putting them in city slums, chasing dreams and fads.  
It's is no technology; it's is an apology to our wisdom.*

So, I think we need a very strong effort to deviate from where we are going. Our direction has to change and we always look for some leader to change that direction. But that leader is not going to be. And therefore, we have to find solutions for this in our education system. There will be many teachers who are realising what is in store and what needs to be done. I think that way, we may avoid the disasters that may be waiting for us.





## *To basic education*



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***Prof. Arun Nigavekar***  
**(Chairperson of the Session)**

*Prof. Arun Nigavekar is a well known educationist having a background in physics. He began his early career as Professor in Materials Science, Pune University in 1977. In 1980, he established the Centre for Advanced Studies in Physics, in Pune. Prof Nigavekar was Vice Chancellor, University of Pune from 1998 to 2000. Under his leadership, the University attained the status of 'University with Potential for Excellence'. He has been a former Chairman of the University Grants Commission (2000-2005) and Senior Advisor and Trustee of the Science & Technology Park, Pune University. A Raja Ramanna Fellow, Prof Nigavekar has also been the Founder Director of the National Assessment and Accreditation Council (NAAC).*

We have had three presentations, all linked with technical education or professional education. Prof Sukhatme gave us very interesting statistics; a hundred-fold rise from 5000 to 500,000—a big jump. Then he raised the question of quality and other aspects. Then we had a success story, autonomy, change, the present situation, and then we had a big question—I mean the IT industry sucking away talented graduates—manpower generation and other issues. Friends, we have only touched the tip. Today, out of 110 lakh students who are in

the higher education structure, only 17% are in professional education. So what we have been talking about for almost two hours was with reference to that 17%. The other 83% are in general education for which a few people have been struggling for the last few decades, because that 83% are still doing their BA, BCom and BSc out of which, BSc accounts for 23.5%. So, I want to change the gear now from the technical to the fundamental or pure or basic education. I invite Prof Mukunda to give his presentation



## *IISER, NISER ..... New trend*



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### ***Dr. N. Mukunda***

*Dr. N. Mukunda did his Doctorate from the University of Rochester, USA and had been Research Associate at Princeton University and the University of Syracuse. From 1967 to 1972, Dr Mukunda was a part of the Theoretical Physics group at TIFR. He was Professor from 1972 to 2001 and Honorary Professor till 2006 at the Indian Institute of Science, Bangalore. His areas of interest are Classical and Quantum Dynamics, Theoretical Optics, and Mathematical Physics among others. He has published 108 papers and co-authored four books. He is a Fellow of the Indian Academy of Sciences, Indian National Science Academy, and Academy of Science for the Developing World. Dr Mukunda won the Shantiswaroop Bhatnagar Prize in Physical Sciences in 1980. Currently, he is Vice President and Editor-of-Publications of Resonance, a journal of science education of the Indian Academy of Sciences.*

I first met Prof Udgaonkar almost fifty years ago. I am aware that many of you here have known him for even longer. But for me, fifty years is a long time. I was a physics student of the second batch at the training school in the Atomic Energy Establishment, Trombay, as it was called in those days. It was in 1958, I remember most vividly even today. We were taught Classical Mechanics by Virendra Singh, Basic Quantum Mechanics by Prof Udgaonkar and Relativistic Quantum Mechanics by S N Biswas. There could not have been better introductions to these three subjects. It is this thorough grounding, my first education in these subjects that explains my own long standing attraction to these areas of physics, especially their formal aspects. Even now, whenever I am confused about the sign - is it + I or - I in the Schrödinger equation? I remember

what Prof Udgaonkar used to write on the board, how he lectured and then put the correct sign in the appropriate place. I was also taught by Prof Menon, the subject being 'Passage of Radiation through Matter'. It was a wonderful course. And who was my tutor? Prof Lavakare. So, I am in the presence of so many of my own teachers.

As we all heard so vividly and extensively yesterday, Prof Udgaonkar has had a lifelong concern for the problem of science education in India. This is an immense area bristling with problems as well as possibilities, and I would like to share some ideas and experiences with you today. Of course, I am painfully aware of the futility of mere complaint. I am reminded of what Laura Fermi wrote about Enrico Fermi. Fermi was a man of simple tastes and thought that complaining was an idle form of expression

directed to no purpose. I like this very much and I think one should always keep this in mind. It is for this reason that I try not to complain, instead, I try to do whatever little I can to help improve the situation and help other people. Looking through the souvenir distributed yesterday, I saw a beautiful photograph of Prof Udgaonkar in Fermi's company some time in the early 1950s.

The problems in higher education in the sciences in India are many, and there are other speakers here who have dealt with them in comprehensive ways. My own experience is limited and I will mention just one or two aspects which are probably familiar to all of you. One thing is the severe shortage of quality institutions, colleges and universities to which interested and motivated students can go after school.

You probably have heard of the *Kishore Vaigyanik Protsahan Yojana Programme* (KVPY) which was established in 1999, and now the Homi Bhabha Centre plays a crucial role in the conduct of this programme. It is supported by the DST. I remember, starting from 1999, every time we held the interviews for students—these were students who were just finishing school, so they always came with their parents—repeatedly, the parents would ask us, “Tell me, if my daughter/son is interested in a career in science, where should I send her/him after school? Which is a good institution?” And they would also ask, “Can you guarantee a job in science?” These days, we often hear the following two statements, and both are true. There is a great drop in the number of students interested in careers in research and teaching in science. There is also a shortage of quality scientists to take up essential tasks in various agencies and institutions. On the student's side, apart from the shortage of good institutions, there are enormous pressures from parents and peers to go for other professions with very attractive—unreasonably attractive—prospects. A sense of balance is lacking, and on the social side this is quite dangerous. On the institutional side, we are all aware of the gradual weakening of the University

system due to poor governance, poor faculty appointment practices, and generally unattractive working conditions in most of the universities. Here, it is worth emphasising that there is a need for both high quality research scientists and high quality teachers at all levels. Yesterday, Prof Raghunathan who was here during the evening celebration repeatedly asked me, “Where are the teachers? How should we make it more attractive to be a teacher?”

This problem must be particularly obvious at this institute, the Homi Bhabha Centre for Science Education. I believe that everything possible should be done to make both teaching and research careers in science respectable and attractive to those of our young people who have the talent for them. Most importantly, parents have to be convinced of this need. Almost three decades ago in the 1980s, well known sociologist M N Srinivas gave a convocation address at the Delhi University, and in that address, he dealt with some of these problems from a larger perspective. He lamented then that (and these are his words) “the young people of today have lost faith in their country”. May be the situation now is not as depressing as it seemed at that time. It would be a damaging indictment to ourselves if we have to admit that things have not improved. But I think they have. Still, everything possible should be done to see that such a statement cannot be made.

Among other things, the contrast between earning capacities and lifestyles of persons in the private corporate sector and those in the world of teaching and research should not be as glaring as they are at present. Some differences are acceptable but not by such enormous factors. This would be socially undesirable and regrettable. Fortunately, there are some recent initiatives which make one feel that the situation can improve, it may improve. We all remember Prof Nigavekar's valiant efforts to create several National Institutes of Sciences in different cities of the country a few years ago. I had the privilege of being with him in this committee. The setting up of a string of Indian Institutes of Science

Education and Research (IISER) and the companion National Institute of Science Education and Research (NISER) is an excellent step and I think it is the fulfillment of a vision which he had at that time. For the first time in our system, undergraduate teaching and quality research would take place within the same institution in a major way. I was very happy to hear Prof Joshi describing exactly this in the field of engineering a short while ago. There have been a few universities doing this already. These new institutions will strengthen links between undergraduate level teaching and the research world. The new IISERs can become a nationwide family of institutes for science analogous to the Indian Institutes of Technology for engineering and the Indian Institutes of Management. For too long, there has been only one Indian Institute of Science in the country, and there too, no undergraduate teaching is done. This will now change at that level.

The idea of undergraduate teaching in a university setting has also been introduced in the last three years or so at Mysore University and at Central University, Hyderabad. As far as I know, it has been there in a few other places also. Apart from this, we have heard that several new Central Universities will also be created soon. But we then have to worry for we need quality faculty in good number, otherwise we will end up creating problems which will take more than a generation to get out of. However, apart from creating new institutions of quality, something has to be done to improve conditions in some of the existing universities too, after an objective selection process. Such improvement is essential in a significant number of colleges as well. Again, I am personally aware of Prof Nigavekar's many attempts and efforts in this direction. In all this, one should also pay attention to the relatively small number of motivated teachers who work in difficult conditions. We have to reach out to them and support them in every way we can.

I would like to mention here, that in several recent sets of recommendations to the Government and to the Planning Commission

that I am familiar with, this point has been repeatedly made, that one has to give support selectively to colleges and universities, revive them, and extend help to those institutes where there are motivated teachers. I would like to read out some of these documents.

In 1994, the Indian Academy of Sciences produced a paper called 'University Education in Science'. In July 2004, there was a SAC Committee report titled 'New Science Education Initiative from 10 + 2 Onwards' and in December 2004, there was a set of recommendations to the Planning Commission from the Indian Academy of Sciences titled 'Support to University Level Science Education Initiative'. Prof Arvind Kumar of the Homi Bhabha Centre for Science Education has been deeply involved in many of these discussions, reports and recommendations which I have mentioned here. A comprehensive document which was drafted by Prof Arvind Kumar was submitted to the Planning Commission in 2006, individually and jointly by the Indian Academy in Bangalore and the Indian National Science Academy, Delhi. I had something to do with all these documents and found that every one of them emphasised the need to do something for our existing institutions selectively. Choose those which have the potential to improve, which have good faculty, and give them all the assistance, apart from creating new institutions with a new style of teaching at the undergraduate level.

Recently, the Department of Science and Technology has launched a very ambitious programme called INSPIRE and this is on a truly massive scale. There are some suggestions along these lines in the Academy's own recommendation and in other recommendations too, but this has been magnified by a very large scale to attract young students to careers in the sciences. The different components of this programme are targeted at students ranging from classes VIII onwards to past PhD age (the early 30s). Once it gets going, the number of students going to be benefitted by this programme will be of the order of 200,000 per year! So, this is

going to be a massive programme. While this is aimed directly at students over a large age range, it is also important that substantial things are done for the existing institutes and teachers as well; at least, I repeat, selectively. Now I come the last item.

At this point I would like to tell you briefly about some reasonably successful efforts of the Indian Academy of Sciences in the field of Science Education Promotion. For the past decade or so, we have been carrying on four kinds of activities apart from the publication of *Resonance* which was mentioned earlier. I will tell you little bit about each of these activities.

Starting in 1995, we have been organising each year, a Summer Research Fellowship Programme targeted at science and engineering students, and teachers in all the areas to work with Fellows of the Academy for two months. From a very small beginning, the number of fellowships had reached 200 for students and 50 for teachers last year (2006). They were all fully utilised. This year, the other two National Science Academies—the Indian National Science Academy and the National Academy of Science of India—have joined hands with the Indian Academy of Sciences. This year, the number of fellowships has doubled to 400 for students and 100 for teachers, and once again, practically all of them were utilised. The joining of the three academies has, naturally, added to the prestige of this effort. So far, about 1500 students have made use of this fellowship working with Fellows of the Academy, and about 375 teachers have also made use of this fellowship. The uniqueness of the programme is that it caters to both groups of people. For students, it provides early exposure to research experience. Of course, it also gives them very good recommendation letters to go abroad, but you cannot stop them. For teachers, it provides a chance to engage in worthwhile research projects and is a great way to supplement teaching activities.

The most heartening thing about the Summer Fellowship Programme is that students from small institutions in small towns or

universities get an opportunity to work at some of the best national laboratories and national research institutions, which otherwise, they would never have been able to see. We encounter many such cases and this makes it a very satisfying and worthwhile programme. I can also say that in an overwhelming majority of cases for both students and teachers, the Guide Fellows who have guided them have found them exceptionally motivated and keen to work. These experiences make one feel that the quality of talent and motivation are there. The real problems are social and institutional.

The second activity is the refresher courses for teachers organised by the Fellows of the Academy in all areas of the sciences and mathematics. They are meant to help improve quality of teaching, both in content and style at college and university levels. In each of these refresher courses, we have had participants from all parts of India, and so far, the total number of these refresher courses has been approximately 50. One outstanding success which in particular, the Homi Bhabha Centre for Science Education might like to know about is the series of nine courses in Experimental Physics. The series have been planned and directed by Prof R Srinivas who was formerly a Professor at IIT Madras, and Director of the Inter-University Centre in Indore. It is almost certain that Kerala University is going to adopt the set of experiments that he has developed, for their Master's level in all their colleges and in their own departments. Moreover, Bharatidasan University has also shown interest in adopting these experiments. The level of motivation at all these refresher courses has been very high even though attending one does not count for career advancement. Actually, it has helped *us* in the sense that only the very highly motivated teachers generally apply and we have been very happy with them. In the Theoretical Physics course which I have also attended a few times, there is sometimes reluctance or diffidence among teachers to come to the board and solve problems in the presence of others. But the

situation quickly improves and confidence builds up. We often get letters saying that these teachers are successfully introducing problem solving activity in their classes and institutions.

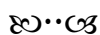
Again, starting in late 1999, the Academy has organised a large number of Lecture Workshops of two or three day's duration. These are intensive lecture programmes in a chosen area which are to benefit both students and teachers, and which cover all areas of science and mathematics. Up to now, we have held 75 such refresher courses. Here, the participants are generally from within a given city, that is, from many institutions in the same city. The numbers that attend is very encouraging; at times, we have had Lecture Workshops with 300 to 400 participants for two or three days. But generally, the number is in the range of 150 to 200 students. I want to emphasise the fact that the workshops have been especially successful in the institutions, colleges, and universities of small towns mainly because such opportunities to listen to good quality lectures is very rare for these institutions.

Starting from 2007-08, these three activities: the Summer Research Fellowship Programme, the Refresher Courses for Teachers, and the Lecture Workshops are being sponsored and supported by all the three National Science Academies in the country. This is a very positive and wonderful step. It is now hoped that there will be a geographical spread of all these activities, courses and workshops to benefit even larger numbers of institutions and students. So far, for understandable reasons but not by intention, the major part of these refresher

courses and lecture workshops has been in the southern states. But now, with the involvement of INSA and Allahabad National University, this should and will change.

Apart from these three programmes, the Academy of Science has also established a tradition of inviting teachers to attend its major scientific meetings each year as guests of the Academy. Again, to give you an idea of the scale, over the years, about 800 teachers have attended and interacted with the Fellowship of the Academy. So, these are the ways in which science teachers and science students all over the country come in contact with the Fellowship of the Academy, and now, it will be with all the three academies. It might be of interest for you to know how many Fellows exist counting all the three science academies. Many are Fellows of all the three or at least two academies. Leaving aside such repetitions, how many scientists in the country are Fellows of one or more of academy? The number is 2000. I do not know if this number strikes you as very small or as significant, but we do count on them for the success of this programme.

I do hope that Prof Udgaonkar will feel encouraged by these efforts to serve the cause of science education in the country. As every one knows, and as I said at the start, our problems are immense in both scale and diversity. So every sincere effort to help, even if it is small in scale, needs to be supported and encouraged. No single formula or solution can be attempted for all our problems. However, at least some large scale programmes have to be planned and undertaken to bring about significant changes.



## *Universities with potential*



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### ***Prof. Arun Nigavekar*** **(Chairperson of the Session)**

*Prof. Arun Nigavekar is a well known educationist having a background in physics. He began his early career as Professor in Materials Science, Pune University in 1977. In 1980, he established the Centre for Advanced Studies in Physics, in Pune. Prof Nigavekar was Vice Chancellor, University of Pune from 1998 to 2000. Under his leadership, the University attained the status of 'University with Potential for Excellence'. He has been a former Chairman of the University Grants Commission (2000-2005) and Senior Advisor and Trustee of the Science & Technology Park, Pune University. A Raja Ramanna Fellow, Prof Nigavekar has also been the Founder Director of the National Assessment and Accreditation Council (NAAC).*

I am going to talk in terms of the 'bullet statement'. There is no need to justify or support any statement because we all know the scenario very well. As far as technical education is concerned, the picture is very clear and great things need to be done, particularly in relation to the quality of engineering education. As Mr Deodhar said, I do agree, whether it is engineering education or the big management education, there is lot that needs to be done. Today, there is a larger demand because they are being taken for jobs which require – I won't call mediocre – but a lower level of expertise and intelligence, and they are being used like that. It is not that engineering graduates are doing jobs for which they were trained; rather, they are doing something different—the IT fever and many other things. The manufacturing and other sectors do require a different type of training.

Coming to the other side; from Prof

Mukunda's talk, I think Prof Udgaonkar will certainly be pleased that these things *have* changed even though perhaps, not to the level that one would have liked. I do recollect that in the mid '80s, we had the big experiment in which we wanted to run the Master's programme in Physics in Pune along with TIFR. Unfortunately, we did not go far and had to wind up after two years because we were not able to attract a large number of teachers. I also recollect going to the TIFR, giving the address in the big hall, and trying to enthuse people. That was the beginning, but we wound it up.

Even at that time, you (Prof Udgaonkar) were saying that institutions like the TIFR or BARC or many other institutions should look very seriously into the education sector. Things have certainly changed to a certain extent. Now as you know, TIFR is itself a university. BARC has also come together and I had a role to play in that. But there was one thing which was missed;

when I was Chairman of the UGC, one of the conditions we had laid down for the TIFR when they became a university was that they start an Integrated Master's Level Programme. But that has not been done, if I am not wrong. Anybody from TIFR here can correct me. It has been conveniently kept outside the domain, and I am sorry, because I am not in the system now. That was also one of the ways, but things have certainly changed.

Another important area was 'Universities with Potential' into which I went very seriously, and Dr Balasubramaniam was one of the persons who helped us in that task. At first, we went for five, then another five and it has made some change. We also introduced 'Colleges with Potential for Excellence in Teaching'. I think that 'selective business' is important and we decided to pick up five hundred colleges. By the time I left, we had selected sixty only. Added to that,

was using Information Technology to make the change across the system, and that is why connecting each and every university was a big thing which we pushed. Each university got the smallest we could give which was 5-6 MBPS. Many universities got 8 MBPS connected and everything was given free – use it. Every college was given dial-up connectivity. Of the six thousand and odd colleges which were supposed to get this, only 2000 came forward. But things are changing though there are many miles to go. I could see that it is not the end because it is a huge country and efforts are being made in many quarters. One important thing: the scientific community is now really seriously taking what we were talking about in the '70s and '80s. They are saying, "Yes, there is sense in that", and that is getting reflected in so many things that are happening today.





## Question and Answer Session

**Questions for Prof Sukhatme:** *Do you feel that the spurt in management education is affecting the growth of technical education? If yes, how to change this? Is the duration of PhD in India playing a role in the production of PhD holders compared to other countries like Germany and China in relation to duration of PhD and growth rate?*

**Prof. Sukhatme:** The first question that I am going to take up is, “Is the duration of PhD in India playing a role in the production of PhD holders compared to other countries like Germany and China?” The minimum specified duration of PhD in India after a Master’s degree is two years. Usually it is three, but it could be four years. A good student finishes in three to four years after an MTech. It is true that in some countries it is less than that. In Germany and even in Russia, you can finish in a shorter time. But it is a question of how you look at a PhD degree; what you want the candidate to achieve in that period of time. Considering what we expect of the candidate in India—whether it is in science or in technology—duration is not likely to be reduced to below three years. That is my expectation. Now, whether it plays a role? Well, it doesn’t really play a significant role. The point is, just now, an attraction for going to PhD is not there simply because a good candidate with a good Master’s degree has other opportunities available to him. That is really the heart of the matter. If he is still interested in doing a PhD, that means he does not want to go for a job. There are enough universities abroad which want him to come there for a PhD and which will give him assistantship. So you see, the PhD programme in India takes a back seat in all this. Abroad, there are many universities with good facilities, and

which are more than willing to have that person. He/she has got a Master’s degree and he/she has got a good career. So that is what is hurting the PhD programme. All of us know the statistics that one out of four PhDs in engineering in the US is an Indian, and two out of four are Chinese. Just now in the US, a substantial part of the PhD programme is run with students of Indian or Chinese origin. They have the facilities, they get good candidates, then if a person is naturally interested in a PhD, that’s where they go first. So, we are battling odds. The duration plays really a secondary role. We are battling odds which are of a different type.

**Question:** *This is regarding OBC reservation. It is recorded this year that 14% of OBCs could clear the IIT entrance examination under the open category. If 27% reservation for OBC is accepted, then greater than 40% will be OBCs. Secondly, reservation together will be 15+ 7.5+ OBC 27% that is, roughly 50%. So, the open category is only 50%. Please comment.*

**Prof. Sukhatme:** There are two questions really. One is that the reservation policy was not implemented in the IITs this year, but it so happens that the IITs had to be ready in case it was to be done. So, they had to ask every candidate, what caste he belonged to. In case it had to be implemented, then you had to differentiate and give the reservation. Otherwise, till last year, we would never ask the person what category he belonged to. This year, the statistics was available that in the general category itself, about 14% are OBCs. This was in fact, informally known to most people in the IITs that on an average about 10% OBCs get into the general

category. But now it is clearly known because the caste was identified during the examination this year. So the question is: will this 14% plus 27% be 40%? Well, it does not quite work that way. What it is going to be once the reservation comes in is not easy to tell. It does not add up simply because of these 14% who got into general category. The moment you say "reservation", OBC students will opt to be in the reserved category. They will not want to be in the general category simply because in the reserved category, they will probably get the branch that they would like to opt for. So you see, it is more complicated that saying it is 14% + 27%. They will opt to apply under the reserved category. Then, how many in the OBC category will come under the 27% is not so easy to tell. But the overall statement that it will be 27% plus something is a correct statement. It will not be 40%, but what it will be is difficult to foretell. Of course, the overall principle which has been thought of is: if some day 27% OBCs get into the general category, then at that point, reservation should be stopped. That is also a statement which has been made. So what will happen eventually remains to be seen.

The other question says, "Reservation together will be 15+7.5+27%". Yes, correct. "It will be 49.5%, so the open category will be 50%". Yes, that is what it will be when OBC reservation is fully implemented. However, at all the universities where this is to be implemented, that is IITs, IIMs, and all the Central Universities where this directive is going to come in, the government has also told all these universities that, "Please do not reduce number of seats in the general category". That means if today, without OBC reservation, we have a certain number of seats X at some IIT or IIM, this X number which is an absolute number will stay the same. The overall number will increase so that X stays the same and the percentages get implemented. That is the position, and it will take three years because if you want to increase facilities, you need time. So, that is why the phase-in period of three years is going to come in.

**Question:** *To ensure quality among students, we have to give them time to understand what is being taught. It is a correct general statement. However all institutions of higher education, including IITs, seem to be interested only in examination and testing. Naturally, the focus of students has also changed to an exam oriented mode. How can we expect other cosmetics changes to usher in quality, if this issue remains unaddressed?*

**Prof. Sukhatme:** Well, the first sentence says, 'to ensure quality you need to have the time to understand'. That sentence is unexceptionable. The second sentence says, 'all institutions, including IITs, seem to be only interested in examinations and testing'. I do not think that is totally correct. To some extent, you *have* to be interested in examination and testing if you want to give a degree at the end. But I would not agree with the statement that all institutions are interested *only* in that. Students are exam oriented, but there is a lot more to education that comes through in good institutions. I really do not agree with this view point.

There is another question on the reservation policy. I had said that phasing-out of the OBC quota over two decades down the line is easier said than done. "When the SC reservation was originally introduced, there was a similar provision to discontinue it in 1970, but it has not happened". I agree with that. That is why I am saying, phasing out should be done gradually. The SC and ST quota is 22<sup>1</sup>/<sub>2</sub> % and the parliament renews it over a certain period saying it will continue. So long as you have a quota and you say, "Well, after five years what do we do"? Somebody says "continue it", it continues as a block quota. What I am trying to say is, give time for any policy to work. If you need a whole generation or two, give that time. Nothing is wrong with that. But then, take one generation to phase it out slowly. That is the way to implement a policy in its totality without creating disturbances. If you do it gradually, it may work out. By making a suggestion as to how we might phase-out, I am not saying that do it suddenly or that it is going to be easy. I am

just suggesting a way out because it has not happened so far. Again, I want to reiterate, we have to implement it first and then of course, phase it out.

**Question:** *Many students prefer to go to abroad to do Master's and also PhD as they believe that the facilities are better abroad. Is there no possibility of large scale exchange programmes at the Master's and the Doctorate level which will expose students to facilities abroad and exchange of ideas? Why don't we think of attracting students from abroad? Their ideas may add to our efforts in lifting the quality in our universities.*

**Prof. Sukhatme:** Yes, there is of course a possibility of large scale exchange and many universities are doing that to some extent, I agree with this. There is nothing wrong with the statement; students want to go abroad because there are better facilities, so obviously we need to improve facilities in India. Why do students—for instance, if they come for a PhD in Science—come to the Indian Institute of Science in Bangalore instead of any other place? Why? Because the Indian Institute of Science in Bangalore has the best research facilities in the country. No question about it. Apart from it, it has the best faculty. Both these things have grown synergistically over a period of time. So, one investment has to be in faculty and facilities. There can be no two questions. You cannot attract good students without doing it. And fortunately, the nation has the money to do it now. Twenty years ago, one could say I can't give Rs 5 crores. Giving 5 crores to IISc was a big thing. Now even for giving 100 crores, the nation does not think much about it. So, the possibility now exists. Why do the best students come for a PhD at TIFR, the few dozens that are taken there every year? Because TIFR has both these ingredients engrained in it – facilities and faculty. We need to build up a whole lot more institutions where we do this. And it can be done. The money is there for it. So, that is why there is a strong plea for putting in those resources. Then we will begin to compete; these

institutions, Central Universities, IITs will compete. The new IISERs will compete with foreign universities and people will want to come for PhDs. So, I think the idea is good, the statement is correct. We go abroad for PhD because facilities are there. But the possibility of creating facilities in India does exist now. The earlier constraints, to some extent, have disappeared.

**Question:** *Why cannot we offer PhD in collaboration with industry?*

**Prof. Sukhatme:** Of course, we can. I do not know the answer to why we cannot. Many people are doing it in the institutions in collaboration with industries. UICT is one of the best examples. Sitting in the heart of Bombay with industries all around it; they have good collaboration between faculty and industry. We need a lot more of it. There is nothing impossible in it.

**Question:** *How could we solve the unemployment problem among science graduates?*

**Prof. J. B. Joshi:** I am related to the chemical industry and I can answer related to Chemistry graduates or Chemistry PhDs. I would like to see unemployed Chemistry PhDs. You bring 10 or even 100 to me, and they will be employed within one day. I have been advertising for Professor's posts or Reader's posts in Chemistry, Physics, Mathematics and I just don't get applications. So, I would like to understand this problem. Where are the unemployed people? Actually, good people are wanted in a big number by the industry.

**Question:** *Many science graduates do not get admissions to technical courses.*

**Prof. J. B. Joshi:** This is a good question, this has to be done in very structured way, and it is an extremely good idea. If engineering education is given in a systematic manner with a science background, and the engineering problems are solved by the scientist, the overall product is expected to be very good. Our institution is moving in that direction. In the forthcoming year,

we plan to offer 20 PhD fellowships starting from MSc in Chemistry, Physics, Mathematics and Biology, and getting a degree in Engineering. However, there are many formalities to be completed. It cannot be started all of a sudden. We have a strong and renowned Board consisting of Prof Sukhatme and all these experiments will be done. Right now there is no possibility, but it will certainly begin in due course.

**Question:** *Many reasonably good science graduates go for research but again there is problem of unemployment.*

**Prof. J. B. Joshi:** I have not understood this question. There are plenty of opportunities. Dow Chemicals in Pune needs 800 PhDs; the Shell Laboratories in Bangalore need 1200 PhDs; DuPont in Hyderabad needs 600 PhDs; Reliance requires 800 PhDs in the first phase. After scouting all through, nobody is getting more than 100 just now. We need to produce PhDs at the rate of 6000 per year so as to meet the requirements. Many educational institutions, including mine where research facilities are good, are also in need. But we don't even get applications for employment, forget about quality.

**Mr. P. S. Deodhar:** This is in reference to my comparison of what is happening in India and China. The question is: "*We should take this comparison to more basic levels in educational strategies*". Yes, I have been studying China from that point of view also. I found it very interesting to know the way education has developed in China since the '50s. They have a concept of learning and earning together even at school level in China. In many places all over China, attached to an educational institution was a production unit and some kind of production was associated with it. This continues even today, far more effectively than it has in the past. Almost two hundred and odd universities today have what they call *Shaubaans*. Many international companies are using these industries for research and development, and the focus is on application research. Today there are 5000 such *Shaubaans*

operating in China with a total production of 8 billion US dollars. They made a profit of 0.72 billion dollars. 40% of these that year were in Beijing and about 18% in Shanghai, the rest being spread out in other places. There is an excellent study by Stanford University on *Shaubaans* and that study is quite revealing. It compares with what happens in US universities in terms of basic research and how industries fork out their investments in universities to carry it out. But US research as observed by Stanford University is more focused on fundamental research, whereas research which is done in *Shaubaans* is more focused on application research.

There is one problem of utilising engineering talent in India (and I am going to digress a bit); I find for instance, that we produce a lot of Electronics Engineers and Telecom Engineers in our country. But I find almost none of them have any knowledge of engineering materials. You may be electronics engineer but you need to handle metal, plastic, and all sorts of materials, processes and processing, and this knowledge is completely absent. Therefore, one of the reasons why their utilisation and employability is severely restricted is because this kind of information which is essential for an engineering graduate is missing. Again, in China, because the manufacturing industry is so large, the demand for engineering is large and the availability of *Shaubaans* ensures that engineering industries in China can get students with proper orientation in manufacturing. One of the exceptions I would say is the chemical and pharmaceutical industry in India where institutes have a scope to participate with the industry.

In India, if the IIT's Electronics department wants to work with the industry in the IT sector, there is no Manufacturing Electronics at all. There is no IC [Integrated Circuits] manufacturing industry in this country. There are some design centres, but by and large, there is no scope for universities to interact with industries because there is no industry.

**Question:** *These days we often hear from various highly placed individuals and sources, including Resonance editorials, that the creation of institutions like IISERs and NISERs has solved the problem of quality education. To use the word of Prof Sukhatme, considering the massiveness of the problem, is not the optimism generated by IISERs and NISERs unfounded? Why support just selected universities? Why are we satisfied by creating 'tiny islands of excellence' and in the process, ignoring the large number of normal universities? Talent and excellence get defined and labeled in this country, too narrowly.*

**Prof. Mukunda:** I cannot answer all these questions, but the first thing I can clarify is that people who write *Resonance* editorials are not highly placed individuals. Second, the IISERs and NISERs are being created to provide more opportunities for young students who are serious about studying science, and it is being done here in this integrated MSc fashion with a lot of emphasis on the fundamentals of science subjects. There are a few good quality undergraduate colleges in the country, but not enough to cater to all the motivated students. So, more institutions like these are created. I am not one of those who say that it has solved the problems of quality education. I will only say, in relation to Prof Sukhatme's statistical data, that they add more opportunities, they provide more places; and from what little I have seen in the first and second year, the number and quality of candidates selected is quite good. So, there are more places where the young and desirous students can go to, that is all that is intended.

Coming to, *Why support selected universities?* Let me clarify my point. The aim is not to create 'islands of excellence' and ignore normal universities, not at all; improve everybody as much as you can afford to, but pay attention to quality. Do whatever you want to improve institutions, paying attention to quality of all kinds—quality of faculty, quality of governance, and quality of facilities which everybody has talked about. How can one do something without paying attention to these three aspects? That would not be meaningful at all.

**Question:** *Why are BARC, TIFR and the IITs the only ones who get all the money, and not other universities? Even in the case of other universities, it is only the Central Universities which are the 'precious stones' whereas, State Universities are neglected.*

**Prof. Nigavekar:** This statement is expressed very often and I don't think one can answer it in a very singular manner. Why it is that somebody is getting more money and somebody less? I think it is a figurative term; may be some institutions are getting good money but this does not mean that others are not. Yes, it requires a larger amount of cake for distribution and everybody should get a fair share. I did put in some effort as Chairperson of the UGC. We did it very seriously but it really requires large changes also. Out of 18,600 colleges, leaving aside engineering and other professional colleges, the number of general colleges was around 13,055. 5800 or 35% of those 13,055 became eligible to get grants in accordance with Form 12B as per procedures, while others were not included to get the UGC grant. These were regular colleges accepted by the state government, but they had no conditional facilities. I did write at a personal level to every vice chancellor and every principal to see that a given college came into this category and became eligible. By the time I left, the numbers increased to 6800. In that 6800, the grant level was raised and the college which was putting in all the applications could get Rs 1 crore 55 lakh. Prof Udgaonkar, if you remember, in the 5<sup>th</sup> and 6<sup>th</sup> plans, Pune University's plan money was 1 crore 20 lakhs. I am not making comparisons but it is a good amount of money. At the state university level, the lowest grant was pushed up almost to Rs 3.5 to 4 crore.

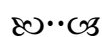
The Central Universities always get a higher amount because their threshold had been decided at a particular level. I made a policy shift that Central Universities would get the same amount of money as they did in the 9<sup>th</sup> plan (there was a lot of shouting over it) and the State Universities would get 1.5 to 1.6 times more. I was trying to remove the gap between the Central and State universities and I succeeded to a certain

level. But I am coming to another point. In the fourth year when I left, I decided to do an analysis of the money absorbed by the system, and here, I was in for a shock. I could see it coming. Out of the grants which were given to various institutions, only 30% was used by the best of the best universities, and I am not going to name it. That means the absorption capacity of our system also needs to be looked into in a different way, and that is why I was talking about governance and many other mechanisms. To sum up, if there are good things happening, it is because there is support which is available to today, and that is where we will have to gear up very fast. Of course, discussion on this can go on and on; there are positive and negative points and I am of the view that every point is correct. The only thing is, have we made a 'delta x' change?

I would like to end with a small story because it is something very important to me. When I tried to push this connectivity, the bigger thing was giving journals to each and every university, free e-journals at that level. Giving the subscription was a Herculean task and I must put it on record that we used the IUCAA machinery enormously, and Prof Kembhavi in particular, put in a lot of effort. A committee was formed, and when the subscription came, had it made a change in the quality of PhD? Because access to journals is extremely important, it does not happen. There are a few examples from Kuvempu University and from Nagaland. That is how I used to come

across all these PhD students. I used to ask, "Are you getting these journals? Are you using them?" I was determined to see what was happening. I will give two examples. One was a lady student in Nagaland doing Ph.D. in Mathematics. She said that she had finished two years of PhD, and when she started getting access to these journals, she realised that the problem she was pursuing had already been solved. So, that was an outdated problem. It happens in our country so often. I do not want to go into it. She decided to change the topic. Within three months of changing her topic, she published a letter to the editor and that letter appeared in a prestigious journal. Consequently, she received an invitation to interact at the global level. I think access does make a change. A similar thing happened in Kuvempu and at other places like Kerala University. I think these are some of the positive things happening.

So, let us end on a positive note. Problems are there, issues are there, and we need to address them and not sweep them under the carpet. But what is a fitting end note today? Yesterday, Prof Udgaonkar told us about the struggle in his mind as to whether to produce research papers or to give time to education. From the time when he was in TIFR deciding to shift his focus from research to education, and the level which we have reached today, is a 'delta x' change. I don't think it is a big change but let us hope that this that delta x soon becomes bigger.



Seminar III :  
Science Dissemination





## *Science dissemination - Role of scientists*




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### ***Mr. Jayant Erande***

**(Anchor person)**

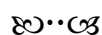
*Vice Chairman, National Centre for Science Communicators.*

*Mr. Jayant Erande did M.Sc. in physics and joined All India Radio in 1976 as programme officer in science cell. Then he rose to station*

*Director's position and ultimately retired as a Deputy Director General*

*- Prasar Bharati. He is a science writer, speaker and has authored / translated books on science.*

Science dissemination or popularisation of science or inculcation of scientific temper is the responsibility of scientists, and Prof Udgaonkar and some of his friends continue to hold this view. Prof Udgaonkar had been the President of the Marathi Vidnyan Parishad, and during his tenure he could motivate the dissemination programmes of this organisation. Hence, it is appropriate to have a session on this subject. For me, this is a very special occasion because when I was doing some work at the All India Radio, Prof Udgaonkar's guidance was very encouraging.



## Science literacy



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### **Prof. D. Balasubramaniam (Chairperson of the Session)**

*Prof. D. Balasubramaniam is the Director of Research at the L V Prasad Eye Institute in Hyderabad. He has been the recipient of a number of awards including the Shantiswaroop Bhatnagar Prize, Indira Gandhi Prize for Science Popularisation, and the Kalinga Prize for Popularisation of Science from the UNESCO. He was awarded the title of Padma Shri in the year 2002. He is Visiting Professor at several Indian and foreign institutes of science. His interest in public understanding of science compelled him to present audio-visual programmes, write 300 articles and six books.*

It is a pleasure and in many ways, a homage that I need to pay to Prof Udgaonkar though he may not know it. When I was an ordinary chemistry lecturer at IIT Kanpur, it was the effort of people like Prof Udgaonkar, Dr V G Kulkarni, and the Tata Institute group which brought out the monthly magazine *Science Today* that edged me on a little away from writing regular science alone and start writing what is now considered to be popular science. *Science Today* was not exactly a popular science thing; rather, it was more like *Resonance* or *New Scientist* or of that genre of science journals. It spoke to the already converted, but it spoke at a level of ease with which even if you were not a member of a particular discipline, you would completely understand. One of the many issues that were raised in that magazine attracted my attention and that is how my very first article in popular science started. So, in that sense, I think Prof Udgaonkar was responsible for all I have done so far; good or bad, it really does not matter.

We have with us today in this session, three

outstanding people: a chemist, a physicist and a nuclear engineer by earlier trade. However, each one of them has given all their recent lives to the cause of science dissemination. In the morning we spoke about science education. Now we need to speak about another aspect of science education which is *dissemination*. If you look at what was happening in India earlier and what is happening today, it is a sad story. There is just one national level newspaper and that too in English, which dedicates four pages on a certain day to science. It actually used to come out with a science supplement but the economics of the trade have brought even *The Hindu* down to 2<sup>1</sup>/<sub>2</sub> to 3 pages every Thursday. There are other English language newspapers today such as *The Times of India* in which you can see a page full of science, but nothing written by Indians. It is really downloaded or copyright permitted material and so on. So, I think it is particularly important that we do address this paucity of science dissemination. Among the regional press, I think it is Bengali,

Marathi, and some of the South Indian languages—though not all, for example, Telugu is particularly poor—which do some science communication, science writing in newspapers, magazines and so on. I know Dr Krishnakumari is here, who has written books in popular science, and apart from that there are dedicated magazines. In fact, the magazine *Chakmak* started by Vinod Raina and the *Eklavya* group now gets translated into a variety of languages including Telugu. But that is not all.

If you look at the major mass medium, which is television today; Indian television has very little. For example, if you are not a scientist, you do not really know the implications of any one of the current issues, be it the Indo-US nuclear deal, or the climate change. This morning's Times of India has it that somebody in Pennsylvania seems to have taken salt water and shown some radio waves of the kind that you use to kill cancer cells. It does not say what kind of radio waves; I do not know if they were positrons or MRI-type microwaves and so on, but these radio waves split the water and set it on fire. Rustom Rai says this is probably because it has produced hydrogen by splitting the water, and hydrogen begins to burn in that heat. We now need to understand; is this true? Or is it another cold fusion type? Or is cold fusion true? Even non scientists need to know some of these issues.

Quite apart from that, you do not necessarily need to know science but you need to be science literate. If you ask someone about music, let us say, an average Indian or a citizen of this world, he or she has basic literacy about music—that there are 7 notes, sometimes 12 or even 21, there is a rhythmic pattern, and you can also put them in melodic motifs and so on. You talk about economics, and they have a reasonable feel for it. It was with this idea that about 15 to 17 years ago, two physicists came out with a book called *Science Matters* which many of you would know. They came out with what they called 20 great ideas in science. I think these are remarkable ideas that need to be disseminated in a variety of ways. I am going to spend the next five

minutes just showing you what these 20 great ideas were. Because what I would like to do is to ask whether would we be able to write a large number of very easy articles or even a 30-second filler on a commercial television channel of the kind that comes today—*Do Boond*, a very effective dissemination of the Pulse Polio Immunisation Programme. The BBC for example, occasionally shows something called Earth Matters; or, before their news began, for 30 seconds, they would simply show water evaporating, becoming clouds, and coming down again...subliminal. It was a very subtle way of pushing in science. Is it possible for us to do that? I am going to just run through the slides and I want you to think about it.

1. *The universe is regular and predictable.* One set of laws is like all motion. Look at the power of each one of these things.
2. *Energy is conserved and it always goes from the more useful to less useful forms.* When I was a graduate student, my professor used to say, "You can't win." That was the First Law of Thermodynamics. No perpetual motion machine. "You can't even break even". That was the Second law. From more useful it always degrades into less useful forms. Is there a way in which we can write about this or even have a 30-second picture? A cartoon? Is something of this type possible? It would be very interesting if someone of us actually tried it.
3. *Electricity and magnetism are two aspects of the same force.* And then comes a bit of simplification but I think we will live with it.
4. *All matter is made of atoms.* Everything. Particles, energy, the rate of electron spin and what-have-you.
5. *Everything comes in discrete units and you can't measure anything without changing it.* You also put in Heisenberg's Principle there.
6. *Atoms are bound by electron glue.*
7. *The way a material behaves depends on the way its atoms are arranged.* Again there is a challenge. Can any one of us think about this

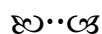
long enough and have, not a 20-minute UGC presentation, but one really much smaller than that? One that brings in this particular idea in a manner that can be seen and broadcast.

8. *Nuclear energy comes from the conversion of mass.* And from that we go back to everything is made of atoms and from particles called electrons. You might want to use some of these, and some, you might not want to use because some of these might be little bit more advanced in terms of perception or even daily needs than others. This item is particularly powerful.
9. *All matter is really made of quarks and leptons*
10. *Stars live and die.*
11. *The universe was apparently born at a specific time in the past and has been expanding ever since.*
12. *Every observer sees the same laws of nature.* Look at the economy with which each one of these sentence is made. I think this is remarkable. This to me is science dissemination for scientists, not even for common people.
13. *The surface of Earth is constantly changing.* No feature on this Earth is permanent.
14. *The Earth operates in many cycles*

15. *All living things are made of cells, the chemical factories of life.*
16. *All life on Earth is based on the same genetic code.* Again, look at the power of these statements.
17. *All forms of life evolved by natural selection*
18. *All life is connected.*

This book, *Science Matters* by Robert Hazen and James Trefil, has been published and its Indian edition is available; the University Press sells it for about Rs 200. There was a lot of discussion about each of these items. *Science*, the weekly professional journal ran a competition: "Can you bring up the number of items any more, have we missed something, or can you make it more economical?" Nobody has done it so far. I think it is very interesting.

These are ways in which I think each one of these can be taken to see if you can build something for science dissemination at what ever level. I know Mr. Deshpande, Dr. Vinod Raina, and Dr Parameswaran are going to be talking about their expertise, and all the wonderful things each one of them has done in the several decades that they have been working in the area of science dissemination; but I would also like to request them to try and see if there is any possibility at all regarding what we just talked about for last few minutes.



## *Marathi Vidnyan Parishad... at a glance*



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### **Mr. A. P. Deshpande**

*Mr. Anant Pandurang Deshpande has an educational background in Electrical and Mechanical Engineering. Although he worked in a well-known petrochemical establishment, his interests lay in literature, music, and science dissemination. This interest prompted him to write more than 600 articles, present audiovisual programmes, and conduct science gatherings. He has published nearly 30 books in different capacities: as author, editor, translator, publisher etc. Mr. Deshpande's role in shouldering responsibility as Honorary Secretary of the Marathi Vidnyan Parishad and as Chairman of the National Centre for Science Communicators is indeed commendable. He has received the FIE Foundation Award, and the NCSTC National Award for Best Effort in Science Popularisation, the Vidnyan Granthakar Prasarak.*

I am going to talk predominantly about Marathi Vidnyan Parishad and the National Centre for Science Communicators (NCSC) and their efforts in the area of Science Dissemination – Marathi Vidnyan Parishad for the past 42 years and the NCSC for the past 10 years. Now, what is the need for the existence of such institutions?

If you consider the past, say 50 years on 4<sup>th</sup> October, 1957, Russia launched its Sputnik. Then, there was a lot of anxiety in society as to what was happening. Why the Sputnik? What is it going to do? What is its use to us? Is it going to harm us? Nobody knew. People wanted to know about it through the newspapers or through lectures arranged by institutions. There were no science institutions existing then, so people went to literary institutions to find out who could speak on such subjects, and there were hardly any. Three to four years later, there was Chinese aggression and war news had started pouring in

the columns of newspapers. Different types of tanks and weapons were being used, but because India had not experienced any war, they hardly knew about weapons and the technology behind them. Again, the same chaotic situation prevailed as there were no speakers who could explain to the common man and answer his questions.

Then the Green Revolution was started in country. Why a Green Revolution? How are you going to apply that? What technology will go into it? How will you motivate the farmers? A lot many questions! And likewise, there were several issues coming up during that period from 1957 to 1965. There was a war again in 1965. So a need was felt for such institutions to exist in society. People started thinking and explaining to society through articles, by delivering lectures and so on. The first campaign was around the science colleges. Could those who taught biology, chemistry, and physics become the lecturers?

Could they write articles and explain to society? Yes. I found that in Maharashtra, at least the first generation of such people were college professors. I remember Dr C S Karve, Prof P M Barve, Prof R V Sohoni were there, and likewise there were many others. After about fifteen years, people from the fields of medicine and engineering also started joining the stream because they felt, "Yes, this is a useful activity; our sciences should also be explained to the larger cross section of society". It was going to be useful because patients or customers would be able to understand them better once the wavelengths matched.

Around that time, the Kerala Shastra Sahitya Parishad (KSSP) also began; Dr Parameshwaran who is present here started its chapter in Mumbai. The Marathi Vidnyan Parishad was formed in the year 1966, and it started spreading its wings in the State of Maharashtra and even outside. These speakers as a first step started informing about various subjects, various issues that were coming up in society. Superstition existed then and it does now too. It has been a permanent issue in India. It exists outside also, but is more intense in our country.

The Marathi Vidnyan Parishad at first organised lectures. There were programmes for school children, but they were in the form of questions and answers because if their teachers could not answer certain questions, those remained in the minds of the students. So, whom should they ask? How should they get those answers? Therefore, such programmes were conducted on school subjects. Experts that existed then were college professors who gave them the information. At the same time, the Marathi Vidnyan Parishad also started a monthly magazine named *Patrika*. It has continued over the last 40 years till today. Another useful activity was the Translation Workshop. A lot of literature had to come from English to the regional languages; to us it was Marathi, and so we organised the translation workshop a methodical way. How was it done? At first, we focused on translating whatever was available into our own

language. Such a scenario existed from 1966 to 1982. When Prof Udgaonkar became the President of Marathi Vidnyan Parishad in 1982, he brought a change; new ideas started flowing in. Prof Udgaonkar felt that we should select a few subjects and so, five subjects were selected: Land, Water, Energy, Health, and Science Education. He also was not in favour of assigning topics to workers. The workers should be choosing a topics for work out of their own interest he felt. School exhibitions, small workshops, and experiment workshops for the students, and workshops for college teachers were organised on these subjects. Competitions for students were also organised.

Around the same time, we felt that there was a big necessity for imparting gender education to children. A slide show that had been produced by an institution known as *Aastha* was already available then in Mumbai. We purchased the audiovisual show and started showing it in schools. However, there was a stiff resistance from school teachers to show such a programme. We were refused in some schools, whereas in others, initially there was acceptance but then some senior teachers objected to it and we had to cancel the programme. In some schools where it was shown, the management came in for criticism from parents because the children had informed their parents about the topic of the lecture and slideshow. But later, from 1982 to 2007 or in the last 25 years, the programme is becoming more popular and the earlier resistance is absent. If at all there is resistance, it is from the Government. Recently, the Maharashtra Assembly had banned the gender education programme due to some political reasons. When my colleagues went to meet the Education Minister, he assured us that it was a political game and they would revert to it in the next assembly session.

However, this programme has become very popular and I think about 5 lakh children have seen it so far. In fact, our earlier programme was for girls only, but later there was a demand for boys' programme as well. So we produced that

programme too. At the end of the 40-minute slide show, a question and answer session is also organised. Initially, children do not come forward to ask questions but later on, when the lecture is over, they gather around the person who has shown these slides for asking questions. We found that many of these questions were repetitive, hence we produced a booklet on these questions and answers. Yet, many institutions have not come forward to show such gender education programmes. Incidentally, one or two pharmaceutical companies produced this programme, but with a motive of selling their sanitary pads.

I remember, I was once attending a meeting in Delhi, and the NCERT and some other institutions expressed their interest in showing the gender education programme. It was as if the Central Government was going to give us responsibility for the entire country. We cannot take the responsibility for other states; yet, we trained some people from Madhya Pradesh and now those programmes are shown there as well. In the State of Maharashtra, it is extensively shown through our institution; however, several others including our other chapters have purchased the slides from us and the programme is being widely shown. The demand still exists.

One programme that Prof Udgaonkar encouraged was to gather the 10<sup>th</sup> and 12<sup>th</sup> standard children and give them some idea about careers in science research. We did one such programme at Podar College in Matunga in 1985 where there was a gathering of 500 to 600 persons; half of them were children and half were parents. The programme was liked by the parents, the children understood it very well. But it was Prof Udgaonkar – a different personality – who cautioned us not to be content with one programme and advised us that continual efforts were required. Still, it took us three years to organise our second programme which we did at Vaze College, Mulund. Between 2003 and 2005, with the help of the DAE, we organised about 100 lectures consecutively at our chapter places. Last year, Prof. J. B. Joshi Director of the UICT

suggested that we organise such programmes at every *taluka* place in Maharashtra; where there are 353 *talukas*. The lectures on careers in science research would be delivered by the PhD students of UICT. We could get about eleven students last year, and 69 lectures were delivered by these students going to 51 *talukas*. The students were overwhelmed by their experience because they felt that their knowledge was tested by the school children. The way they were asked questions, the type of questions; not all the questions could be answered by these PhD students. So this year, we organised such programmes for the remaining 302 *talukas*. We had organised a meeting at UICT recently, and 60 PhD students were to participate in the programme. Each would deliver five lectures; so 300 lectures will be delivered in all. It is hoped that these PhD students will at least remain in their respective fields, because as Mr Deodhar explained, there is so much aggression from IT that IIT, medical and other graduates are suddenly changing their disciplines and going for IT—PhDs are no exception. So with this experience at least, if they can retain their fields, we will be particularly happy.

With the emergence of new issues such as load shedding, we started conducting solar energy workshops which included solar cooker fabrication for two days and solar water heater fabrication for two days. This was to enable people to learn how to harness solar energy use it. Is it really true or are people just saying it on paper? Another problem experienced by every citizen throughout our country is garbage disposal. How to dispose it off? How to segregate and how to re-cycle it? We have made a garden on the terrace of the Marathi Vidnyan Parishad, wherein all fruits and vegetables are grown by using this bio-degradable mass. So, we are carrying out various types of programmes.

We have also started an Encouragement Prize Scheme for college students to carry out short research programmes for a year, for which funding comes from the CSIR, BARC, some other institutions and even from some individual

donors. In fact, when we first started this programme, the money came from an individual. This encouragement scheme has been going on for the last five years. After the National Centre for Science Communicators got established in the year 1997, we started a course in Science Journalism. Such a course was not previously in existence in Maharashtra. There were general courses in journalism run by various institutions. We completed ten batches in all, some in Marathi and some in the English language. While scanning the headlines of newspapers today, one hardly finds any science news in the first, second or third pages. I remember, before Dr A P J Abdul Kalam became the President, he had delivered a lecture in Hyderabad in which he said, "A few days back I was in Israel, and there, whatever new methodology was developed in farming – that occupied the front page news. Palestine's attack on Israel was on the 3<sup>rd</sup> page". I do not know when we will see such a situation in India. Last year, when we had a conference in Delhi, I was seated next to President Kalam and he suggested that we start something like a special channel for science on radio, on television, a special newspaper for science news, and the like. I think these are intensive activities that will remain a dream for an institution like ours – or for that matter – any dissemination organisation in India.

Oure another activities include publishing a few directories through the NCSC. The Directory of Science Communicators has about 600 entries and the National Directory of Science Communicating Organisations, both Governmental and Non Governmental, covers about 300 institutions.

As newer types of information keep pouring in, science teachers often find it difficult to teach new subjects. Hence, we had organised the Teachers' Workshops in which we invited experts from BARC and TIFR to address various issues in teaching. This activity was very successful.

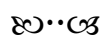
Organising conferences for science

communicators has been one of our important activities and we did this in the years 2000, 2003, 2005, two conferences in 2006, and the present one this year.

Now with all the work that has been done over the last forty years by the Marathi Vidnyan Parishad and ten years by the National Centre for Science Communicators, I still find that gender education remains a problem in our society. Teachers are unable to explain properly certain concepts that are mentioned in the textbooks and students are unable to understand them at all. The Marathi Vidnyan Parishad has started a Concept Development Programme from the current year [2007]. Experimental back up is needed to understand concepts; instead, students learn science almost like history. Teachers simply explain the experiments orally and the students have no access to carry out these practically. That is where persons like Arvind Gupta come into the picture. He has developed many experiments using household waste material.

Superstition is an evergreen subject. Cleanliness and waste disposal are challenges in our society. Pollution is another big threat. We do not get water in the first place, and then getting good clean water is another problem. All the diseases that are occurring are an account of pollution due to solid wastes and bad water. In Maharashtra, there is a prize scheme called *Nirmal Gram Yojana* under which prizes are given in the name of a saint, Sant Gadge Baba, to villages which are cleaned best by their inhabitants. Now, 300 villages have got such prizes so far and a newspaper report says that whenever a village gets this prize, the public dispensaries there do not get any patients. So, this further reinforces a direct relationship between cleanliness and health.

Energy is another problem, and I find that there is always a shortage of volunteers to work for such programmes. I hope that with the intervention of many institutions and the media, more people get attracted to such programmes.





## Science - Chaos in complexity



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### **Dr. Vinod Raina**

*Dr. Vinod Raina is a science activist as well as a social activist. He is the co-founder of Eklavya in Hoshangabad District, Madhya Pradesh and has worked as its Director for ten years. He is also a co-founder of the All India People's Science Network and the Bharat Janavidnyan Samiti.*

My Chairperson is Dr D Balasubramaniam, but affectionately, Balu. I am going to disappoint him because I am not going to talk about science dissemination. I am going to talk about something that is bothering many of us; with so much of science dissemination, science promotion or popularisation, *why is it not working?* I do believe it is not working. Therefore, I am not going to go into what we started to do; I am not going to give anecdotes of *Hoshangabad Vigyan*, but I am doing something and sharing with you what we have started doing in the All India People's Science Network which is—reflection on what is happening in the enterprise called Science. I have spoken with 140 main leaders of the KSSP (Kerala Shastra Sahitya Parishad).

I know very clearly, that even though we say that science is a critical knowledge and we need to be critical, but once we are critical, we are also accused of being pessimistic. No one wants criticism beyond a point because then you become pessimistic. So I would like to forewarn you that it is not to spread pessimism. The other problem is that if you do something

unconventional, you could always be misunderstood, and worse, corrected.

Prof Udgaonkar, Menon, Balu, Lavakare and many more such people in this country are regarded by us as Nehruvian. And it has a very specific meaning in terms of both, science for development and science as a source of reason. That is what Nehru actually tried to project for independent India, and the term Nehruvian was commonly used to describe people who used science for purposes of interacting with society. What I would like to suggest is that, the trouble with science dissemination probably not being so effective is because—and I could be completely wrong, it is open to debate—when we talk about science for the last 50 years, the relationship of science with society as it existed 50 years ago has changed considerably. The problem I find in approaching science from outside is that, whereas it has changed considerably, our methods have remained the same. So, can we have a reflection to say how it can become more effective, because that relationship has completely changed? So, in this first decade of the twenty first century, as science

has advanced as never before, we are witness to a bewildering phenomenon of the undiminished brutality of science in support of war – whether in Bosnia, Iraq, Afghanistan, Kashmir or elsewhere. We are also witness to the increasing retreat of reason in a world that is dominated by religious fanaticism, and the commodification, privatisation and marketing of science for personal or corporate profit rather than for public good. One of the most pro-reason person in this country is a non scientist—the lyricist, Javed Akhtar. If you interact with him you will see that he believes in rationality. So, there's reason to ask Javed to pen a new song, "Where have all the Nehruvians gone?"...but not all, as Prof Udgaonkar is sitting with us in this conference. He, along with the other 80 year 'young' person, Yashpal; they are young romantics who, in spite of all the destruction and violence that engulfs us—a lot aided by advancement in science—have refused to part with the hope that science can benefit both, in improving the conditions of the deprived masses, and as a fountainhead of reason to confront irrationality and injustice. And if some find their romanticism naïve, so be it; since the world seems to have a greater need for precisely such naïveté today more than it ever did. That's my tribute to him.

So, what has gone wrong? What has gone wrong to prompt us to say that we require this kind of naïveté? Balu was telling us about *Science Matters*; it is a wonderful book and we have had many similar books in the last twenty years. Such books have given us science in a refreshingly different way. But I would also like to add that we have had three or four very important books in the last decade, which are very disturbing. One of them is *The End of Certainty* by Ilya Prigogine, and you cannot dismiss Prigogine; not just because he was a Nobel Prize winner, but because he has made some very important observations that science cannot give us certain knowledge. The second book is by an equally illustrious Nobel laureate in Physics, Leon Lederman, called *Science: the End of a Frontier?* The third book is by a very persuasive Scientific American writer,

James Horgan. It is called *The End of Science*. It is no longer science as the end of a frontier, no longer end of certainty, but the end of science itself. So, what in the last decade has spurred some of these very sensible people to talk about the 'end thesis'?

Well, there are some visible symptoms such as the decreasing number of students who are attracted to the sciences, a massive upsurge in dependence on faith and religion to show the "path" – even political – to solve problems, the idea that science won't solve problems but faith will, and the link between egalitarianism and science based on the notion of science as a public good that has got considerably weakened. But at a deeper level, while probing the functioning of Nature—which is the very reason for science—Nature itself would appear to have been vandalised from the knowledge gained. Environmentalism is a very inadequate term to describe that. We do say environmentalism, but while we know more about Nature, we also seem to be vandalising Nature at a greater rate. Finally, from within science, aspects of Quantum Mechanics, Chaos and Complexity have raised questions that seem to suggest a limitation to the enlightenment promised – that science will reveal all. So, there is the crisis.

Just about a year ago, the current Scientific Advisor, C N R Rao wrote a letter to the current Prime Minister highlighting the grave situation about the children in India turning away from science. He gave enrolment data from class X onwards, up to colleges – and it is alarming. The number of students not taking up science is really alarming. It is something that has happened last year in India and it has been formally known. However, it also happened in US two decades ago, so it is not just an Indian phenomenon but a global one. Children don't want to do science in the same numbers as they did before. Combined with the continuing pitiful investment in research and development in the sciences, the decrease in the number of students has made the situation appear very grim. Not only are our students opting out, but the Indian State does not seem to

be bothered to rectify the gross under funding that has plagued Indian science for years.

Someone was saying in the morning, “there is lot of money now”; I don’t know how that was said. I know that in education, at least in 2002, we touched 4% GDP as education spending. And even though the present government has a common minimum programme promise to increase it to 6% during its tenure, it has fallen from 4% to 3.52%. So, when someone was saying in the morning that money is no problem, I was just wondering where that come from, certainly not from figures.

There was great hope at the time of independence—accompanied as it was with partition and the violence emanating from extreme religious hatred—that in a deeply religious and superstitious country like India, ushering in of the scientific temper would help create a more rational future generation. It was constitutionally mandated that while they would be free to retain their religious faiths, Indian citizens would assert to forms of open debate – the essence of a functional democracy – respectful diversity, and a secular and rational behaviour, at least in public life. A considerable amount of work at the grassroots by science movements and disseminators has traditionally been directed to such purposes. The situation today in 2007 is however, alarming. The efforts of science groups – and this is what I started with – look particularly feeble compared to the sustained media onslaught by the increasing number of TV channels devoted fully to religious dogma, or other channels devoting increasing airtime to irrationalities such as numerology, astrology, *vastu*, *feng shui*, *bhoot* and so on. Even cricket is no longer exempt from such intrusions. A channel will call a sports analyst for predicting the result of a match the next day and end the programme by asking an astrologer to foretell the results. Educational curriculum is constantly under stress for inclusion of faith based material, be it in history, evolution, sciences or teaching of values. In spite of widespread protest, astrology and *karmakand* got a nod for inclusion

in teaching courses during the previous NDA regime – a decision that is yet to be formally reversed by the current “progressive” UPA government.

As if that was not enough, imagine 1947, the kind of enthusiasm and the Nehruvian paradigm being brought in; I don’t know, perhaps people here who were born then may probably tell me, but I feel the idea that a Hindu nationalist political party would rule secular India was perhaps unthinkable at the time of independence. Nor would it ever have been possible to predict (this I know for certain) that in the 1960s, the Cold War confrontation between US and USSR based on the ideological conflict between capitalism and socialism, would be replaced in the beginning of this century, by a world order with two other global axes—Islamic fundamentalism versus an increasingly Christianised United States. It is unbelievable and unpredictable. The next important book that is debated in scientific, academic and intellectual circles is Huntington’s *Clash of Civilizations*. The description that the present time is a clash of civilisations rather than a clash of ideologies, and the clash of civilisation is a clash between Christianity and Islam, taking you back perhaps, into the mediaeval times of the Crusades. And it is amazing that with so much science happening, people should actually be writing that we are in the era of “Clashes of Civilizations”.

There is enough research to show—and I have worked on this when I was on a fellowship at *Teen Murti*—that Nehru was very much influenced by the Left European scientists, in particular by Bernal, and he had a great regard for Bernal. But Bernal belonged to a tradition of Left European scientists to which Halden, Hogben, and Joliot-Curie (Joliot-Curie was a member of the French Communist Party) also belonged in the 1930s. Bernal in particular, not so much by his four volumes of *Science in History* but by his seminal slim little volume *Social Function of Science*, influenced a whole lot of people in the post colonial world including Nehru, as I said. His thesis was that science has

a much better prospect for improving the life of the masses if it can be organised under the State in the newly emerging countries rather than in the capitalist western countries. In capitalist countries, science would only aid profit making in a capitalist world. But if it is under state control in the newly emerging nations, then its potential for benefitting societies is greater. When Nehru invited him to come to the opening of the National Chemical Laboratory in Pune, there was an interaction between them which was very important for understanding the changing relationship between science and society. I would say that the KSSP was deeply influenced by this, and my understanding is that KSSP's slogan 'Science for Social Revolution' emanated from this view of using science. However, this link between science and society is now under... I don't know how to look at this link. With the fall of the Soviet Union, and country after country being coerced into or opting for integration with the global market, ideologies appear to be falling in line with the market. China has embraced the market through its least understood 'market socialism'. I have been a frequent visitor to China for the last 14 years and I have been teaching a semester there. It is a bewildering situation. All I can say is, even with a communist party leading there, it is not a socialist country. What it is, I am not able to describe. There is no word to describe China of today. All one can say is, it is not socialist. So therefore, we have ideologies falling in line with market. Consequently, skepticism has overtaken the old link between science and egalitarianism and socialism—which even Einstein espoused, putting under a considerable strain the notion of science as a public good. I think this notion has come under a great strain today.

As graduate students in the early '70s, a joke on the campus used to be that if just three persons—Newton, Maxwell and Einstein—had their theories patented, perhaps 99% of everyday human activities would be required to pay royalties to them—for motion, electricity, and energy. You press a switch you pay to Maxwell,

you take a bath you pay Newton, you do anything with energy, you pay to Einstein. So you would be paying these three people all the time. It was inconceivable then, that such a regime would ever operate. That it took less than 25 years since then, for the 1995 patent regime under the WTO to be drafted, sounds incredible. True, that scientific theory is as yet outside its ambit but algorithms and life forms are not.

The question is not what is covered just now and what will be in the coming years. It is the impact it has on the notion of science as a public good that is devastated. Gene patenting is completely frightening. It was assumed that one could patent processes that make available new inventions not directly available in Nature. Nature's products could not be patented. But genes are Nature's products. If you give monopoly rights to them through patenting, that in effect says that you could convert aspects of Nature as personal assets and then trade them for earning profit. This amounts to colonisation of knowledge and aspects of Nature, in a manner similar to geographical colonisation wherein inhabitants of a country, mostly Europeans, reaching another country first, would end up claiming it. So, the person isolating a gene first can claim it as his personal property, including the person from whom you took the gene. It would reach some very interesting level that the line from which the gene came, also belongs to the person who might patent the gene. There is a wonderful book on this but I won't get into that.

So consequently, whereas in yesteryears, good scientists like Prof Udgaonkar, M G K Menon, and Balu would brush up their oratorical and writing skills to share science with lay people in an entertaining manner, they are perhaps today closeted with patent lawyers, learning skills of keeping knowledge away from public through patent proposals. How can such science regimes ever be egalitarian, socialistic or in the cause of public good? Therefore, whether it is in the area of science education, spreading reason and scientific temper, or the role of science in the developmental process for

creating an equal and socially just society, the changed nature of the relationship between science and society can no longer be viewed as it was before. This would demand a serious review of our visions and perspectives which are mostly derived from our understandings prevalent from the '30s. But since science is a global body of knowledge, let us look at this global skepticism. I mentioned to you about Lederman. Lederman did a research survey in 1991 which was published as *Science: the End of a Frontier?* I would exhort you to read this book. I think it is very important for us to know what came out of it.

In this, he contrasts today's (and these are his words) "mood of uncertainty and discouragement" about science with the hopes of the post war years. He writes, "Once upon a time, American science sheltered an Einstein, went to the moon, gave the world the laser, the electronic computer, nylon, television, the cure for polio, an observation of our planet's position in an expanding universe. Now however, things look different". Lederman was the President Elect of the American Association for Advancement of Science at that time, and therefore he arranged for America's leading scientists to be sent self-completion questionnaires. It was these questionnaires that he got analysed, and these are the views about contemporary science and its organisation. The results reveal widespread gloom. I quote, "The response paints a picture of the academic research community beset by flagging morale, diminishing expectations and constricting horizons. From one institution to the next, across demographic categories, across disciplines of research, the nation's scientists were sounding a warning: Academic research in the United States is in serious trouble." Lederman suggests that the common theme underlying public and government attitudes towards science is a "loss of faith in the future". This is in total contrast to the bold optimism of the scientists of the past, in the 17<sup>th</sup> and 18<sup>th</sup> century. The pioneers of modern mathematics and science were imbued

with a sense of boundless possibilities science offered in the service of humanity. Back then, science was at the cutting edge of philosophical and cultural advance. Then, the growth of science ideas undermined the dogmas of religious authorities and raised the prestige of science. Despite the two World Wars and colonialism, and distinct doubts about its prospects at times, science and confidence about it survived intact for much of the twentieth century. The spirit of enquiry and experimentation which had once glowed during the period of enlightenment continued, though in a manner suited to the Cold War, which was very often to subordinate pure science for the demands of the military.

Separately, I would like to tell you that science was in fact booming during the Cold War years. If you consider period between 1945 and about 1980, science was at its highest peak and many of our stalwarts here who were researchers during that period do remember that. But that's about it. After that, a better life to a happier people through better science appears to be an unlikely prospect, if not an impossible dream for a large discerning humanity. Contemporary disillusionment with the science brought by its alliance with military and war, ravages on nature through over production and over consumption—global warming is an example—and the diminished belief in its intrinsic power to tell us the truth, have given rise to prejudices and hostile attitudes towards particular branches of science. There is a researcher who has looked at 54 Hollywood films which had something to do with science, in the last decade. And she concluded that out of these 54 films, there were only two films which said something positive about science whereas, 52 films showed science in a negative light.

Science movements are therefore no longer challenged by taking ideas of science to illiterate and toiling masses only. It is the very large highly educated middle class endowed with most of the advantages that science and technology have to offer who through the 'Art of

Living' classes, Osho inspired parties, Maharshi Meditation Centres, *feng shui* and *vastu* Masters—a clear indication that they reject the condition of human progress based on rationality. For the illiterate, lack of knowledge of science and belief in the supernatural would be attributed to a historical social condition. For the vast educated masses, ignoring science and rationality as a basis for human progress, and to seek it through commercial spirituality is a decision based on choice rather than ignorance, for the middle class. The middle classes are not doing it because they are ignorant; they are making a definite choice. The toiler might still perhaps be amenable to an argument of human progress based on reason, but that is also being undermined by the escalations that are being manufactured by the visible educated middle class making him believe that the road to happiness is after all to be found through blind faith in the ancient scriptures; or miracles like when Ganapati drinks milk mostly in the presence of middle class people and their ally, the television camera.

There is some thing internal to science that has brought in a lot of skepticism in the last fifty years. There are three things internal to science. One is very well known, and which was mentioned by Dr Balasubramaniam—the Principle of Uncertainty. It has ever remained a problem in the philosophy of science. Essentially, it tells you that an observer can disturb the system that he is observing. That is at the heart of the uncertainty principle. That you are uncertain about position and momentum because the moment you observe the subatomic particle, you disturb it, so you cannot predict both together. So, there is an uncertainty in the system. This is called the major problem. Einstein tried to fight it saying that it violated causality; and this violation of causality has a larger philosophical reason, which means that the notion that enlightenment reason had that nature was independent of the observer. So, the idea that you had an objective reality which you could see and verify independently came in doubt. And it has

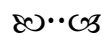
never been over come. It has never been over come, even though there are aspects of quantum mechanics which were fine, but this was the first part.

The other two internal problems with science as *certain* knowledge come from chaos in complexity. I won't get into them, but I will refer to them. Though they are usually confined to weather or dissipative systems, the trouble is that people elaborated on them and said, "They are not only true of certain systems, but they are true for the whole of nature". You cannot predict nonlinear systems, which is what chaos and complexity are about. And this is what Prigogine's book *End of Certainty* is about. You cannot certainly predict, because there is unpredictability. The famous sentence all of you probably work with, "The flapping of wings in Brazil can bring on an avalanche in the Himalayas". It is so uncertain that you cannot predict. So, between quantum mechanics, chaos and complexity, and let me tell you it is not only what Prigogine did, for which he won the Nobel Prize. Yesterday, Prof Menon was referring to Gell-Mann many a times. Gell-Mann is a great promoter of the unpredictability thesis – that nature is unpredictable – and science cannot find it. You cannot be certain. So, you have problems. This unpredictability, combined with the work of two particular persons, has shaken the foundation about science being the way to achieve the so called final truth. It has to do with logic or scientific discovery of Popper, which essentially says that inductivism is not a valid scientific way of verification. It attacks inductivism. Though Russell spent a huge amount of time trying to counter Popper, I think Popper's thesis about induction not being a verification of science has not really been countered. And add to that Thomas Kuhn's paradigm thesis that science works in revolutions in paradigms. That is fine, it does. But the devastating thing is that the paradigms do not communicate with each other. They become independent and there is relativism in science. These three intrinsic problems have given rise to

a whole lot of intellectual work, which seems to suggest that there is subjectivity and relativism in science, just as they exist anywhere else. Therefore, for science to say that it is a better method than, say religion, is not philosophically correct. And I don't think we have known how to counter this.

I have already mentioned about science ravaging Nature, and the fact that from a whole lot of work that you would call environmentalism, people say today that this world would be more peaceful if it had less science. There probably would be fewer wars, and less ravaging of Nature which is the basis of life itself. Therefore, the general public view is, "can we have less science rather than war"? And therefore we have a problem of how to approach science dissemination in the wake of such a view point.

Does it mean that as scientists and disseminators we should be retreating from science? No, this is not what I am saying. What I am saying is, we are confronted by questions which are different today, than they were in 1950—whether it is in the relationship of science; the way science has got commoditised and marketised (and it has now); whether it is in terms of science and its relationship with other knowledge systems – particularly religion – in terms of saying that science is a superior and a more rational way of acquiring knowledge; or whether it is in the thesis that science can offer us a better human progress. All I am saying is, at an individual level we are happy about what we are doing, but when regarding science as an enterprise, we need to reflect and refine our techniques better.



## *Nature, Science and Society*



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### ***Dr. M. P. Parameshwaran***

*Dr. Parameshwaran is a science activist and a social activist. He has a background in Engineering and has been a scientist at the Bhabha Atomic Research Centre (BARC). He has been deeply involved with the Kerala Sastra Sahitya Parishat (KSSP) and is considered to be its backbone. He is also the Chairperson of the Bharat Janavidnyan Samiti. Dr. Parameshwaran has been involved in various activities of the National Centre for Science Communicators since its inception. He has authored 30 books on science in the Malayalam language, 3 books in English, and has published more than 300 articles.*

Most of the people, who have talked to us yesterday and today, have had a *Guru-Shishya* relationship with Prof Udgaonkar. I too am not an exception. I must have been one of the earliest students of his reactor physics class, first batch of the same school. Incidentally, my first book written in Malayalam was on the Nuclear Reactor Theory. The popular book explained what a nuclear reactor was and how it worked, to high school children. My later relationship with him was on a different note. We came in close contact again in the '80s, and in 1987, he joined us as President of the National Organisation for conducting the *Bharat Janavidnyan Jatha* and later, the All India People's Science Network. Whenever I came to Mumbai, I used to visit him and we would share a lot of concerns about where we were heading. Is it a progressive movement? A Science movement? or a Left movement? Where the country is going? Where the world is going? These have been the recurring themes of our conversations.

The question is, where are we going? Now, Vinod Raina has placed certain areas before us,

where we have to be—I will not call pessimistic—but careful. I too was reading a book which showed that things are improving beyond doubt. Whether it is availability of food or life expectation or any element, whatever we had a thousand years ago or a hundred years ago, by comparison, today things have improved. World is simply improving and there is nothing to worry about. If at all there is worry, it is of a very philosophical nature on which the future is based—science as an enterprise is questioned. But apart from that, we also know that the present upward or positive trends observed are not sustainable from the viewpoint of science dissemination. Now, what is that science and what is science dissemination for? Anyway, I have not been bound by another's decision; instead, I defined my own boundaries as far as science dissemination is concerned.

As Vinod Raina said, one thing is certain—the knowledgeable middle class is irrational by choice. Now, if this is allowed to continue, how can the poor, less fortunate or deprived people come out of their deprivation? What hope have



they got? Will it lead to a violent revolution where they kill everybody else and save themselves? It is neither desirable nor possible. What are their conditions of redemption? How can they enjoy what others are enjoying; with at least the minimum amount of food, clothing, shelter, education, and health care? We know that **if** today's knowledge level in science—and it is a big 'if'—is shared freely and allowed to operate freely, the afflictions of society, whether poverty, widespread diseases, water shortage, or transportation, can be solved. But today, that 'if' is a very negative 'if' because knowledge is non-shareable. As he was saying, it is a commodification and knowledge is now a property – Intellectual Property Rights. To me, one of the most vulgar words in the English language, or in any other language is 'intellectual property'. So, it is in reaction to that concept that I would like a place for science popularisation. It is not just for science popularisation, it is for breaking the concept that knowledge is not property, knowledge is to be shared. And by definition, knowledge is knowledge only if it is shared. If it is only for oneself, it is actually not knowledge.

Now, there are people following several streams of thought. We have the BJP, the Congress, the CPM and a variety of political parties having their own ideologies and lines of argument about how to redeem the poor people and improve their condition. But do they tell the people the truth? How do people find out whether somebody is telling the truth or not? How do people judge what they hear or see? If they are not able to do their turn, they will be misled, and most of them are being misled. Everyday, we have several situations where we are being consciously misled. So, one of the things science popularisation should do is to help prevent people from being misled. People should be able to analyse for themselves and arrive at conclusions. And for that, they should have information, knowledge, and the capability to analyse.

When we speak about science

popularisation or dissemination, we have to analyse it a little. Yes, information is required, but it is not enough. That information should be able to provoke them to question, "Is this information correct?" and if somebody has given incorrect information, then to ask, "Why did you tell us something that is incorrect?" We have to provoke them to question in this manner. So, one of the functions of the science disseminator or populariser is to inform, and the other one is to provoke. So, there is informative literature, informative communication and there is provocative communication.

I will give you a simple example of provocative information: The Kerala State Electricity Board in late '70s declared that Kerala was going to be in total darkness unless a particular power station was built immediately—The Silent Valley Hydroelectric Power Station. The KSSP, of which I am an active member, felt there were other ways of providing Kerala with power. In our view, the Silent Valley was a very valuable forest with great biodiversity and there was no necessity to destroy it at that point. Prof M G K Menon knows the story because he came as part of an enquiry commission to investigate that case. The type of literature published at that time, for about two years, was highly provocative and made people ask questions. They not only questioned the Kerala Electricity Board, but also the KSSP. From that provocation, came vision. What was the energy needed for? Then it led to the whole concept of what is development? What is energy? If the whole of Kerala got energy, then what about the particular area—Malabar, the northern part of Kerala—for which the Silent Valley Project was planned? Are there other ways of producing energy? A whole set of discussions focused on this issue and a new vision for development of Kerala emerged from that—what you can call envisioning or creating new ideas. So, communication should inform, should provoke, but also help to envision and create new thoughts and new ideas. So, these three elements are important in communication.

Now, before going into the activities of the

KSSP, I want to place some facts before you. I was speaking about the All India People's Science Network of which Prof Udgaonkar was the first Chairperson and later, the Bharat Janavidnyan Samiti of which I am the current Chairperson. Vinod Raina was its former Secretary. Now in Maharashtra, we have the Marathi Vidnyan Parishad, Lok Vidnyan Sanghatana and Bharat Janavidnyan Samiti—all the three belonging to the category of People's Science Movement. All over India, there are about 30 to 40 such organisations. There is an organisation in almost in every state, and the combined membership of all these organisations will be about 300,000 (primary membership). These organisations can today reach out to about 250 to 300 districts in India. There are district committees in more than 200 to 300 districts. So, this is not a small organisation. I do not know how many political parties will be having contacts at this level with so many district activists? I am speaking of political parties because they are supposed to be the most widely spread group. So, it is a sizeable, major organisational entity existing today.

I would like to tell you very briefly how all this came about. I will submit that the All India People's Science Movement in India came from three streams. One stream, I call the Kerala Consensus (like the Washington Consensus). The Mumbai Consensus is the second stream and the Moscow Consensus is the third stream. These three streams came together. The 'Moscow Consensus' came through me. Mr. Deshpande was telling about October 4, 1957—the launching of Sputnik creating some terror and fear in the minds of people. For some people like me, it was one of the most exciting things that made me decide to go to the Soviet Union to study, and I went there. At the institute where I was studying, there were about thirty people working for a PhD. We were discussing amongst ourselves about what we would do when we went back to India, other than our professional work. Ultimately, we came to a consensus that one of the things we could do without being questioned by the Government departments was

popularisation of science in Indian languages. That was in December, 1964. We had a New Year's gathering on the science popularisation movement.

I am very happy to have been associated, from the very foundation, with the Marathi Vidnyan Parishad—even before a formal meeting took place. I used to meet Mr M N Gogate, Prof P M Barve, and Dr C S Karve very regularly during those days. Marathi Vidnyan Parishad's foundation day was in April 1966. In August 1966, a meeting was called at the TIFR, of people who were interested in popularising or disseminating science in Indian languages. Prof Yashpal took responsibility for the Punjabi language, Mr M R Srinivasan for Kannada, Mr M K Rao for Telugu, Mr R R Daniel for Tamil, and Dr Divetia for the Gujarati language. We again came to the conclusion that we should do popularisation up to the high school level. Whether we should go to the university/college level, whether it was necessary, whether it was advisable, was a different thing. We then formed small groups. The Marathi Vidnyan Parishad had already become an organisation. The Malayalam organisation was also in existence. Tamil, Telugu, Kannada, Hindi and Gujarati were there too. So, seven organisations for developing science literature in their respective languages were in existence, and all of them together formed the Federation of Indian Language Science Association (FILSA). Dr R V Sathe, who was then Vice Chancellor of Mumbai University, was President of that organisation. This is what I call the 'Mumbai Consensus'.

The Kerala Sastra Sahitya Parishat (KSSP) of Kerala had started in 1962, initially, as a very small organisation. It was only when it was reinforced by the Mumbai Consensus and the Moscow Consensus that it became critical. Till then, the KSSP was just a group of about 30 to 40 people, but from 1966 onwards, it started expanding. The KSSP is involved in science communication in number of ways. I do not want to elaborate and spend too much time on that except to tell you a few important aspects.

One aspect is that KSSP uses written words very profusely; it publishes books in large numbers. Every year now, it publishes Rs 1.2 crores worth of books and sells them. The sale is done by members going from house to house, school to school and office to office and not through regular bookshops. The purpose of doing it this way is to have all the distribution commission coming to the organisation. In the process, we save about Rs 50-60 lakh, which is the money for the entire organisation to function at all levels. It is not dependent on any grant from anybody. About 95% to 98% of the KSSP's work is done voluntarily by otherwise employed persons who give 2 to 3 hours of their time on working days, the whole day on weekends and a few days on holidays. So, several thousands of person days of 'activist time' are given for this work through these members. That gives us, and should give all of us, the strength.

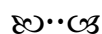
Now, to mention a few figures: Out of 800 books published in last 30 years, 150 books have sold more than 10,000 copies, about 40 titles have sold 20,000 copies, and 2 titles have sold one lakh copies. And they are not small books, they cost about Rs. 200 to 250 each. Written words or a book is only one of the ways of communication. Additionally, we have been engaged in a very massive way by spoken words—what you call Lecture Campaigns. In one particular campaign called 'Nature, Science and Society', we had 12,000 lectures or interactions you can say, in one month with 500 to 600 people being involved in it. There would be some interaction or the other everyday. This has been translated into various other languages, and is being done in other places also. To give you a glimpse of the contents of that lecture, the main points conveyed were:

1. There is nothing outside the Universe.
2. The Universe was and is always present. A concept that there is no beginning and no end, in the sense that the question 'what happened before the 'Big Bang' is not prohibited.

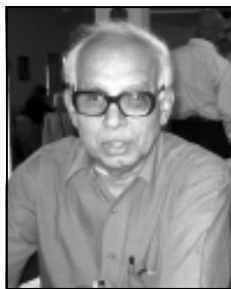
3. Change is a mode of existence of universe. Everything changes.
4. In the Universe, everything is related to each other. (Some of this was seen in the 20 points shown earlier)
5. Mind, consciousness, and emotion, all of them have a physical or material basis—the brain
6. Different life forms are products of long term evolution
7. Principles of science such as generalisation, abstractness, codification etc. are built in the structure of human language. So language is the first vehicle of science. For instance, when relating cow to animal, or crow and pigeon to bird, there is an element of science in it. In the very early days of science, science was not differentiated from actual life. So, from life, evolved science.

These were the main things which we were trying to impress upon people. In last 15 to 20 years, we found that speaking about science is not good enough. Ultimately, the bulk of the science is kept alive not in books, but in the fields and in the production process—a field or a factory. So, for the last 20 – 30 years, KSSP is spending as much time on the field, as it is through words both printed and spoken, for science popularisation.

Finally, I come to the type of feeling or the type of expectation one wants to provoke and envision. Not only do we have to provoke people to question "Where are we going?" but also dream "Where should we go?" I feel convinced myself, but I do not know to what extent we have been able to convince others that tomorrow *can* be better than today. Just simple words—tomorrow can be better than today. We do not say 'will be' or 'would be' but 'can be'; and if it has to be better, then something has to be done today.



## *Science as a public good & Science for the public good*



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### ***Prof. D. Balasubramaniam***

*Basically a Biologist, Dr. D. Balasubramaniam rose to the Director's position of CCMB, Hyderabad. Professor and Dean, University of Hyderabad and currently Director of Research L V Prasad Eye Institute of Hyderabad. He proficiently writes science in Hindu and many other periodicals. He is recipient of Kalinga award.*

We had three different types of dissemination talks. One was Deshpande, who talked about the efforts starting from the early '60s, thanks to the Marathi Vidnyan Parishad. How effective the Maharashtra group has been really in disseminating science, in engaging people at all levels! It has turned out to be a vibrant organisation. The second is an even more elaborate and widespread example that Dr Parameshwaran talked about regarding the Kerala Sastra Sahitya Parishat. I did not realise these facts about the Moscow Consensus and Mumbai Consensus. One could see how the idea came about and how their mode of delivery or dissemination is qualitatively different from the Marathi Vidnyan Parishad's approach. As he said, they have taken on issues or looked the issues in a larger personal engagement mode; to inform about a given issue, you ask, you provoke, you let the people ideate and attempt to resolve the issue in their own minds. Clearly, here is one example where the community participation is there with very little money or effort coming from outside, rather, it came from inside. When he talked about 12,000 lectures on one subject—that

is a colossal number! It is very clear that the KSSP has been the torchbearer and has also been one of the major initiators, promoters and sustainers of the *Bharatiya* effort itself. So, here are two examples where we can certainly look back with some satisfaction. And as he says, tomorrow can be better.

But looking at 'tomorrow can be better' is really where Vinod Raina's thesis comes about. He is worried about a variety of things including how the entire societal ethos towards science has changed. And should not therefore, science dissemination also change its mode to deal with this newer—non-Nehruvian if you wish—ethos that actually confronts the disseminators now? I think it is extremely worthwhile to throw the floor open to discussion on these various aspects of science dissemination.

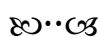
Just to recapitulate, the major themes here were: Science *as* a public good and science *for* the public good is a concept that is slowly giving way in the last one generation. The second is, what you see as use or exploitation of science is not just to understand Nature, but to exploit and even rape Nature. That seems to have been one great

worry of people. And the third is clearly, what the public itself feels to some extent, based on what Vinod Raina talked about in the Prigogine and Lederman papers which are somewhat of a philosophical worry about the way science is progressing. Is it an end of the frontier of science? Hardly seventy years ago had Vannevar Bush written about the *Endless Frontier*, and now we are talking about the *End of the Frontier*! So, among scientific thinkers themselves, there is great tumult that is happening. Looking at how science (and technology even more than science) has brought about destruction, whether it is warfare or any kind of ill effect that you see; the middle class, the literate mind itself has changed in a manner that is not necessarily inimical to science, but certainly one that does not engage in science with as much conviction or vigour as it really should, and therefore, they also turn to other attitudes, their own mind sets and so on.

Only two days ago, I started reading this remarkable book by an atheist and a remarkable zoologist, Richard Dawkins. Many of you would have read Dawkins' *The Selfish Gene*, *The Blind Watchmaker* and *Rivers of Eden*. But three years ago, he wrote a book named *The God Delusion*, the Indian edition of which is now available at Rs. 280. It is a remarkable book that poses a variety of questions. It actually places faith and

reason exactly facing each other. He of course, takes his position very clearly and even talks about 'Einsteinian Religion' what we normally consider as 'Received Religion'. What should it be? Could one even be an agnostic? That is another question that is asked. I read the reviews about Dawkin's *The God Delusion*; whether it is The Guardian, or The New York Times, or The New Yorker (I don't recall having read it in the Indian papers, not because they have not written, rather, I have not read it), invariably, almost all of these papers just pose the question of "how terrible" rather than "how engaging" this should really be to an intellectual mind. That too, in a way reflects the societal ethos—and in journals like The Guardian, it is surprising.

With this as a back drop, it would be very nice to have a discussion for the next 20 to 25 minutes on all these aspects: regional efforts in popularisation and disseminating science; where does this type of dissemination movement go? Should we also change the tactics, strategies and approaches towards disseminating science? And placed against such societal ethos, what should we, as a collective group of science disseminators do? As Dr Raina pointed out, many of us would continue what we had been doing in our own little way. But we have been given a wake up call and it is important that we discuss this.



## Question and Answer Session

**Question:** *Is there any other movement in the nation which is like the KSSP or coming close to KSSP?*

**Dr. Parameshwaran:** Well, today there is no other movement which is on par with the KSSP in the sense of not requiring any external help. However, there are a few movements such as the ones in Tamil Nadu, Karnataka, and Andhra which could function on their own without any external support by means of book sales and other activities. The Himachal movement is another example and gradually, Bihar may also join the league soon.

**Question:** Actually I had a couple of questions earlier for Dr Vinod Raina. But the way you summarised the session provokes me to ask this question which always confuses me and it is like this: there are two distinct aims for which science popularisation could be done. The first, in my view is to make people understand what science is. The second (from the way it indirectly comes through your summarisation) is that when people are interested in science popularisation, they act like missionaries to convert a theist into an atheist. *So, is this the aim of science popularisation, to invoke this dichotomy which may not be there, and then convert them from theist to atheist?* This is the first question.

The second question which I had for Dr. Vinod Raina is: he talked about the uncertainty of scientific knowledge and gave arguments which come from within science and not from science's interaction with society. I think we did not really wait for quantum mechanics to tell us that science is uncertain. Most of the scientists always knew that and Hume is an example. He beautifully told us two and half centuries ago that

science is uncertain. But how does it reflect on the credibility of science? *There are two different issues – uncertainty and credibility of science. So, does uncertainty really affect the credibility of science?*

And the last thing is about the way he talked about Popper. *In my view, Popper never dealt with problem of induction. In fact, we thought that the problem of induction, and in general, the problem of discovery of knowledge is beyond the capacity of philosophy. I mean this is not a philosophical question. It is a question to be dealt with in psychology.*

**Prof. D Balasubramaniam:** Very well, since the fault of summarising was mine, I will try and answer that question and you can worry about the credibility and Karl Popper. I have been writing popular science for the past 30 years now, and it is not with an idea of converting anybody – let us make it absolutely clear. If I find something as a professional scientist, in the professional press, or something that has recently come out as a development of one branch of science, and I simply share it with others—this has been my approach. So, it is not talking down or talking up. Let me give an example. It has nothing to do with science as it were, but a larger fabric that includes science.

I have been reading a few books by Jared Diamond who is a zoologist and an animal physiologist. He wrote a book called *The Rise and Fall of the Third Chimpanzee*—the third chimpanzee being us! His second book is *Guns, Germs, and Steel* and the third is *Collapsed*. Almost a month and a half ago, three of my colleague friends, Umashankar, Ganeshayya and Patil wrote an article in the 'Current Science' on the *Rise and Fall of the Vijayanagara Empire*. It was about how this empire started, flourished under

Krishnadevaraya and how it ended, and there was a remarkable similarity. They also noticed it. They asked a question in *Current Science*—why is it that kangaroos are abundant in Australia, camels in Sahara in Africa, and jaguars in Latin America? The other question was, why did the Vijayanagara Empire start in Hampi? There is a connection between the two and it was very interesting. They actually made comparisons and what they showed is essentially: Firstly, where the entire group makes the most of the environment around it. It is an ecological adaptation, exploitation and so on. The reason why kangaroos flourished, still flourish, and hopefully will flourish tomorrow is for the same reason as what has happened with this empire. A kangaroo finds a variety of natural resources, climatic and other conditions very good in Australia. Similarly, the Vijayanagara dynasty found it very good because they had, first of all, favourable opportunities to get local resources like sandalwood which was very important. Secondly, horses suddenly became more available, thanks to Europeans who set sail and came to India at that time. Until then, horses came from the Arabs from the North, but now they were able to buy much faster. And the third reason was the natural resource—diamonds. These were the three reasons and they talk about these in great detail.

To me, it is a very interesting thing. Now, I am not teaching anybody, rather, I am just learning about it. So I wrote about this. Suddenly, it occurred to me that this was a different kind of dissemination and popularisation which is, being given a topic and asking “how do you do it?”

The third kind is for example, what KSSP and Parmeshwaran have been doing. In that sense, there are so many ways of doing it.

The second question had to do with the uncertainty of philosophical moorings of the scientists themselves versus the credibility of science. Vinod Raina might need to talk about that.

**Dr. Vinod Raina:** People knew about the uncertainty of science, so what is new about it?

It would require a much longer interaction. We are not talking about the uncertainty in trying to do research and not getting an answer. You have to understand what happened in the 17<sup>th</sup>/18<sup>th</sup> century Europe with one man called Newton. The impact was not on science, the impact was on everything that had to do with society and life. In particular, the articulation in the enlightenment backed by Roger Bacon and Rene Descartes that it is a superior knowledge. It is a superior knowledge compared to anything else—then, it was Christianity and therefore social and political systems should be based on it. That is not a small change. The term ‘Secular State’ came in at a time when societies and nations agreed that the Church and the State should be separated. And that was the impact of science. It did not come on its own. What we say in our constitution today, “India will be a secular society” is a remnant of that form of impact of science which said that religion and the state should be separated. Even though religion can legitimately be in the private domain, it will certainly not be in the public domain. That was the impact of credibility and the certainty of science; in a sense in which Alexander Pope wrote his famous lines – “Nature and Nature’s laws lay hid in night. God said let Newton be! And all was light”. So poetry took it, the arts took it, governance took it, social systems took it, and that was based on this clearly defined relationship between reason and science. That reason was the ultimate key to understand the working of Nature and therefore you could not separate them; and this was accepted in all forms of reason.

It is not a question of what Hume had said. There were many people writing against Newton at that point of time. Goethe had a running philosophical battle with Newton about theories of light at the same time – contemporary. So, it is much more than Hume. You can identify many more people. But you have to realise the impact of the enlightenment on Europe at that point of time; and from there onwards to rest of the world through colonisation.

To understand that when within science and not entire science, to my mind, you come to (in quantum mechanics, problematic) philosophical moorings that, may be, this notion of objective reality doesn't exist every where. The trouble with it is, if you find one violation as a scientist, as a mathematician...you may have a theory and a theorem in mathematics, but you require just one violation to disprove it. You might find ten million verifications, but one violation and it violates a theorem. In a similar sense, when you have this theorem that science is ultimately the key to truth, and you find that in subatomic particles, causality and objectivity get violated – it is a big problem. The other problem is with chaos and complexity. I think in science dissemination, this is what we should talk about—that it is a needless extension from very restricted systems to the whole world. But it has been taken up. I am very surprised that some one like Murray Gell-Mann should say, "What happens in weather and dissipative systems can be extended to life and Nature as well". That I think is a debate, but I don't think those leads or extensions are actually done by science. But for a kind of person like Gell-Mann to get into that and say that it may be valid...?

Your last question was about Popper. Let us not get into semantics here. You might have read *Logic of Scientific Discovery*. The problem was: can you verify in science? That is inductivism. What Popper said was, "You can never verify; you can only falsify". There is no way you can verify and therefore, 'falsification as opposed to verification' is at the heart of inductivism in science. The debate between him and Russell are very well known. Russell tried to counter him all his life because Popper was actually attacking the very basis of what we call science. There were examples he (Popper) had given. The best example is that for years we believed in Newtonian mechanics and everything was verified in Newtonian mechanics. But now, Einstein's relativity says that Newtonian mechanics is not correct in many situations. What

do you make of all the verification? It is a very well known debate.

**Question:** *Middle class is "irrational by choice". Can we expand the scope to science dissemination to address the above concern?*

**Dr. Raina:** When we talk about science, popularisation, and science dissemination in the Nehruvian paradigm, in the Bernalian paradigm, all we were talking about was how science could benefit society—the downtrodden, the marginalised. We talk about them and this was the vanguard, for this was the middle class. But the worry is, we used to say that we need to inform them, make them aware, and bring reason into them so that their superstitions would go away. Then we would have more reason and a better life. We are concerned about them and this is central to what I am saying. In this, it was expected that if people became educated, they would become more reasonable. Therefore education and dissemination of education, which are different from each other, were seen as vehicles for making people who would be more reasonable.

What are we confronted with worldwide today? When we say New Yorker, Washington Post, or The New York Times actually not engaging with Dawkins, there is a problem. That is why I said that the axis has become Islamic fundamentalism versus an increasingly Christianised United States. And if you have a middle class which wants to believe that the road to progress and happiness after all the cell phones and Maruti cars, is the Art of Living Class or joining Osho Centres, we have a big problem. Where is the vanguard, which will convince the toiling masses that reason is the way to do that? And I would like to clarify that reason does not mean you convert theists to atheists. I think it is wrong to put it in a binary way. It does not mean that at all and that is why you should read Dawkins. You can keep your belief in something, it may not be God in the form of man, but that does not mean you become an unreasonable person. For science dissemination, science



awareness and so on, our target today or our problem today is how to reach the middle class rather than the people in the villages. There are ways and we are discussing that. But that would require a separate session. There are ways, but the approaches would be different. It is not by telling them what nanotechnology is, and showing new researches in science. It won't work like that. That is all I have to say.

**Question:** *It is admitted that science is the best instrument for asking certain questions and finding answers to these questions. It is also known that it is very powerful in improving in the standard of life and so on. But life is much more than all these in the sense that there are questions which a scientist is not competent to answer. For example, what is the purpose of life? Or, how do we connect with the universe? We use science to learn about the Universe but not to learn about how as human beings, we connect with the Universe? How do I love my neighbour? There are no answers for this in science. So, I don't think we have to find fault with the Art of Living or other such courses, as they are enterprises for answering such questions without in any way diminishing the functioning of science. If they appear to occupy more space in newspapers today, maybe it is a passing phenomenon which will change with time when science comes forth and answers more questions.*

**Dr. Raina :** I completely agree with you. I have no quarrel with that except when it goes to the level where a certain other knowledge system tells you that God will love you more if you attach a TNT device to your belly, sit in a room and let it go, and kill fifty people there; that is a better way to go to God, than anything else. When that reaches those stages that "it is coming from a commandment of God that I should destroy myself along with others, then I will reach God...and it is the surest way" – then we have a problem!

The trouble is, we have moved to those levels today. If it remained at the level of the kind you are trying to say, that there are certain aspects of human life which today are not answerable by science, and therefore if there are human

interactions which are based on many other relationships while we do our science, there is no problem. But when you move away, at least pay attention to the fact that the world power axis today is based on what Huntington calls 'Clash of Civilizations'. I think we should engage as science people to say that you are wrong. I consider his thesis wrong, I am not agreeing him, but it is a problem. That is where we have reached today.

I have spent time working in Kashmir and Afghanistan, and I can tell you that whatever we might talk about here, out there are young people now being educated where that is the reasoning, and it is frightening.

**Dr. P. Lavakare:** *As Parameshwaran mentioned, Intellectual Property Rights is the worst word that has now come in. Could it be ignorance on the part of the Nehruvian thinkers that could have brought us to the state that we are in, namely, the misuse of technology, wrong way of going, and therefore the blame coming on Science?*

**Dr. D. Balasubramaniam:** There are two things to that, it is not just that alone. Intellectuals from other branches of human knowledge are now constructing something that is totally ridiculous, which is called the Post-Modernism Concept. This post-modernism is perhaps the most devastating thought one can think of. And that worries me because you talked about Huntington at least; but there are scientists who wrote against him. I think the most eloquent anti-Huntington essay came from an economist, Amartya Sen in his book. He too criticised the post-modern concept. He says, whatever you say, I can just pull the rug under the entire frame because the whole thing is a human thought and you will be left with nothing but a vacuum. Post modernism leads to nihilism of various kinds.

**Dr. Raina :** This thesis is very old, as you know. Is something wrong with science or something is wrong with the way the science is controlled? So, it is a use-abuse model. You can use science for good purposes, you can use science for bad purposes and it is dependent on who controls it. It is not the scientist but the politician, the

bureaucrats and so on. We have had this for long. When you say that science and technology are different; and I do say it in my paper, I call it 'gadget science'. What gets supported today by the States is gadget science. You must in your proposal say, that at the end of your three-year research what gadget (gadget is a metaphor) you will produce that can be "useful or do something for society"; whereas, science works as a free enquiry that you are not clear about what. But if you look at trends...and you know very well yourself, the very fact that the superconducting supercollider was not supported, signalled that pure science will not be supported—that was not technology. That was basically a support for probably the weakest part of science. I did not believe in 1993, that it would not be set up and no money would be given for that. There is enough evidence to show from Europe, US and other countries that signalled that states and governments were not prepared to fund pure research at the level it was in the past. And that is what I call 'the decline'. And I am not yet talking about technology; I am talking about pure science. That is happening across the world, and that is frightening. If governments are not funding pure science, that means they have the backing of the masses not to do it. Because if they

are a democratically elected state, then there would be evidence to say that the masses want that support. It is frightening that it is not only technology that's being destructive in terms of better weapons of war and so on, it is the fact that unless you can tell me that from your research something is patentable, you can tell me that your research will give me profit...this is why, if they are vulgar words – intellectual property rights regime. The point is we are now in a paradigm where science must be commodified and if it is not commodifiable, then it is not relevant science. It is junk. In that paradigm, which otherwise for human civilisation might be a very important thing to do; but that's not to be supported. It is this paradigm we have entered. I am not joking. I know countries (I do not know about India. I don't keep track of the science establishments) which now don't have summer schools in Theoretical Physics. They now have workshops on how to write patent proposals, and the best scientists are taken into these workshops with lawyers to say how to write a patent proposal. I know these workshops are held, the best scientists are made to go there and their proposals for funding must say that how they are going to convert that into a commodity.



## PROGRAMME

12th Sept., 2007

**13.00 to 16.00 Hrs.**

### **Seminar I : School science education - Universalisation with Quality**

Prof. Ram Takwale - Electronic media for teachers

Prof. Anita Rampal - Road map to changing science education

Mr. V. G. Gambhir - Activities at School level

Prof. Jayashree Ramdas - Curriculum based talk - innovative curricula in science

Dr. K. Subramaiam - Math education - innovative curricula in mathematics

**17.00 to 20.00 Hrs.**

### **Felicitation to Prof. B. M. Udgaonkar**

Mr. A. P. Deshpande

Mr. Suhas Naik Satam

Dr. Savita Ladge

Dr. Manasi Rajadhyaksha

Dr. Anil Kakodkar

Dr. P. G. Lavkare

Dr. Anil Sadgopal

Prof. Arvind Kumar

Dr. Padmanabhan Babu

Dr. Jayant Udgaonkar

Prof M G K Menon

Prof. B. M. Udgaonkar

Dr. Hemchandra Pradhan

13th Sept., 2007

**09.00 to 12.00 Hrs.**

### **Seminar II : University Science and Technolgy**

Chairperson : Prof. Arun Nigvekar - Overview

Participants : Dr. S. P. Sukhatme - Pressing issues in higher education

Prof. Arun Nigavekar - Alternative pedagogy for higher education

Prof. J. B. Joshi - New avenues in higher education of technology

Mr. P. S. Deodhar - Networking universities within, with industry and society

Prof. N. Mukunda - Strengthening science research

**13.00 to 16.00 Hrs.**

### **Seminar III : Science Dissemination**

Chairperson : Dr. D. Balasubramaniam - Overviews and his experience

Mr. A. P. Deshpande - Marathi Vidnyan Parishad.... at a glance

Dr. Vinod Raina - Experience of ekalavya and context of gender education

Dr. M. P. Paraeswaran - Activities of KSSP and Sarva Shiksha Abhiyan.

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