Making science simple

Jayant V. Narlikar

One of the most important questions facing us today is how to popularize science in the twenty-first century, how to help people appreciate science as a part of their culture. We can divide this challenge into four different aspects: primary education, secondary education, higher education and the general public.

In *primary education* the fundamental thing which one has to develop in schoolchildren is a curiosity about nature. Children generally start with this curiosity, but our education systems often suppress it. This must change. Next to be developed should be the concept of a pattern in natural phenomena. Then slowly the mathematical aspects should be introduced – the idea that what nature is doing has a quantitative aspect to it. Next to be revealed is the predictive ability of nature, the hallmark of science, the fact that nature is following certain laws and therefore one can say what is going to happen next. If these aspects are introduced and incorporated into primary education, children will begin to appreciate science as an important part of their education. One of the problems in teaching science is that of comprehension. Many children go to English-language schools and when they start learning science, they first have to translate the concept from English into their first language, in which they understand it best. There is a double effort involved. My personal experience has been that when someone starts out in their first language, the progress is much smoother. I feel that a problem today is that this is not emphasized.

Another problem of a practical nature is class size. In India, we

have sixty or seventy students to a class. This makes it difficult for the teacher to have a personal rapport with the children.

Coming to *secondary education*, the main issue here is to emphasize the experimental verification of scientific laws. We should not be learning to accept a fact because the teacher said so; we should be learning by the scientific method of experimental verification. Experimental verification, replication and error bars: these are intrinsic to science. There must be a do-it-yourself approach to science.

The next important step here is the historical development of science through the interplay of theory with experiment. I find from hindsight that if the history of science is taught in a way that shows how scientists actually learn by making mistakes and correcting themselves, then children will better appreciate and understand how the subject develops in a natural way.

As regards *higher education*, the main aspects here are: (a) access to additional source material beyond classroom teaching and texts – textbooks are not an end in themselves; (b) student–teacher relationships – students need to be able to discuss, ask questions, argue and interact with their teachers at the higher levels of education; (c) confrontations with research frontiers – science is progressive and students should see research being carried out around them; and (d) project work – students should have the satisfaction of doing projects, of finding out what interests them. They should be given the opportunity to add to the overall content of science. In this way, a student can discover his or her own likings. Students often do not discover what they really like until it is too late. In India we find that many would-be scientists become doctors or engineers because of lack of encouragement to do project work.

The fourth aspect is *science popularization for the general public*. One of the critical issues is helping people learn to live comfortably with science and technology. I think it is easy to view these subjects as something that has no relevance to daily life. It is important to correct this impression so that people are comfortable with science and begin to appreciate and enjoy it. These things can be conveyed in books, lectures and films that are made for the general public. It is also important that science be appreciated for its powers and its limitations. Often scientists get carried away and give the impression that science will cure all. Then there is a backlash from the intellectual community which asks: how can you offer answers to everything when you yourself know that science is incomplete? This greatly weakens our position. The solution is to share the failures as well as the triumphs.

We also need an appreciation of the importance of basic research. Often basic research is downplayed in developing countries because they cannot afford it. In India it has been demonstrated that basic research is fundamental to the application of science.

In India we currently face a number of problems in popularizing science. First, for students making career choices, other professions are more attractive than science. Universities with too many students cannot maintain good teaching standards. Second, research institutions have slender connections with universities (where potential brain-power resides) and industry stands very much aloof from the universities. 'Intimate' contact with students is missing on these fronts. Third, the educated lay person has a slim grasp of what science can do. But often this person has a great curiosity about science. One must tap into this curiosity. Finally, at all economic and educational levels, there is a disturbing lack of the scientific temperament.

In assimilating science and technology into a society, it is important to understand the limitations of science and what that society needs in terms of old and new values. This is the job of science popularization. What follows are approaches we have taken at all levels to bring science closer to people.

At the *university level*, in my own research centre, the Inter-University Centre (IUC) for Astronomy and Astrophysics, our basic objective is to provide advanced-level facilities for all universities to use. Because of a shortage of funds, we cannot give each and every university advanced facilities in astronomy. But we have created them in one centralized facility at Pune. The strategies under which this IUC was created – there are other IUCs in other fields – involve sharing national facilities among universities. I would like to see this experiment carried out in other subjects also.

Apart from our high-level research we promote *educational activities for children*. We sponsor monthly lectures and demonstrations for schoolchildren; summer projects for schoolchildren (we invite them to spend a week in our centre where they do very modest projects but have the satisfaction of having hands-on experience); national Science Day, which includes many festivities of a scientific nature in which schoolchildren participate; and something I personally do, 'postcard correspondence'. When I give a public lecture, students will often ask for autographs. I reply that I will not just give an autograph – they must write me a postcard with a scientific question. So this child must put in a little work for an autograph (I also must do more work in answering the questions). I collect a lot of postcards and of course, I always reply.

We also have many *public-oriented activities* including amateur astronomy programmes and public lectures. We also use all the media in different ways to propagate astronomy. At the Homi Bhabha Centre we have programmes for better comprehension, better textbooks and better science teachers. We also have a pilot programme encouraging children who, because of economic conditions, are not usually able to have access to science teaching. We have voluntary organizations that take up social issues in a scientific framework, and a Science Cavalcade that goes on the road and performs plays and magic shows, which are then explained in terms of chemistry and physics illustrations. This Cavalcade has considerably improved the appreciation of the villagers. We have published books that bring science closer to the community. These are not textbooks, but rather easy-reading books. Some of our government organizations act as catalysts, not in the sense that they take on these activities directly, but they give some support and this has proved extremely useful.

Looking at the state of science education and science popularization in my country, one sees that many things are positive, yet there is much to be done.

Multiculturalism, media and education

Mary A. Hepburn

Ten years ago, the Vinson Institute of Government of the University of Georgia formed a special educational division to provide a service for teachers, helping to supplement their knowledge of the social sciences and their civic-education skills. One of the issues this programme addresses today is the need for multicultural education. Another educational issue is the effect of the pervasive electronic media on school-age youth.

Let me first address multicultural education. Among the questions we ask are, what does multiculturalism mean, how should we interpret it and how can we help teachers in public schools adopt sound principles of multicultural education? In the south-eastern United States, these questions are posed against a backdrop of years of cultural tension between White Euroamericans and Black African Americans.

The intent of multicultural education is to broaden the base of a given culture, increasing respect and understanding of other cultures. It is to extend the main culture of a nation – be it the United States, or France, or any nation – and encourage, not just allow, multiple languages and cultures to flourish. This type of education encourages various ethnic groups to contribute to and expand the national norms, vision and values of the existing culture. This approach to multiculturalism can be pictured as a mosaic or tapestry composed of many cultures, each contributing to the meaning and beauty of the whole.

Multicultural education conducted in the spirit of coexistence, mutual understanding and co-operation has been applied with enthusiasm in many schools. My hope as an educator is that civic