CURRENT SCIENCE

Volume 104 Number 1 **10 January 2013**

EDITORIAL

Science in School and College: Teach Less, Learn More

The fact that the number of well prepared high school students opting for undergraduate courses in science is relatively small, has been widely discussed in policy making circles and the media over the past several years. There is a strong perception that the best prepared students entering college overwhelmingly prefer engineering or medical courses, leaving the sciences a distant straggler at admissions time. The drift away from science and mathematics is visible even earlier in the school years, as students move away to commerce and other subjects, often finding science forbidding and difficult. At college level, an archaic description of some courses, engineering, medicine and even pharmacy amongst them, as 'professional' colours public perception. An inescapable corollary of this nomenclature is that all other courses, most notably those in the sciences and humanities, are 'unprofessional' or less likely to lead to employment in lucrative and rewarding professions. The word 'education' has slowly been replaced by the term 'human resource development', implying a shift of philosophy in the arena of school and college education. The rapid growth of private colleges and deemed universities awarding 'professional' degrees, with academic standards lightly overseen by bodies like the All India Council of Technical Education (AICTE) and the Medical Council of India (MCI), has resulted in many controversial situations over the past few years. The award of B Tech degrees in Biotechnology with syllabi (and teaching) that can hardly prepare students for a 'profession' has clearly established that sound 'business models' dominate the sphere of education. The three year undergraduate degree courses in the sciences immediately place graduating students at a disadvantage over the four year 'professional courses', since a further two year Master's program is imposed before students enter research programs leading to a Ph D. 'Integrated Ph D' programs are confined to a few institutions, where additional courses can be organized. There is also a differential scholarship in Ph D programs which distinguishes students from 'professional' and 'unprofessional courses'. Engineering today is hardly distinguishable from the sciences and there is a great need to reexamine the structure of undergraduate courses. While perceptions about college degrees in different subjects may account for declining interest in science courses, there are other issues regarding the teaching of science in schools that merit attention.

In attempting to promote interest in science education the Government has attempted many experiments. In all major policy interventions, in recent years, schemes to provide financial incentives have been the most visible. Money is a universal carrot and scholarships of various kinds are now available to entice students leaving school to enter undergraduate science courses. The Department of Science and Technology's Kishore Vaigyanik Protsahan Yojana (KVPY) program was a forerunner of the INSPIRE fellowship scheme; both of which have been growing in strength. New institutions, the Indian Institute of Science Education and Research (IISERs) that offer undergraduate science education in a research environment have been started. Old and venerable institutions like my own, the Indian Institute of Science, have started four year, flexible undergraduate programs which may motivate students towards careers in science. These experiments are only a small step and the verdict on the outcome of these initiatives will undoubtedly become known only years later. Schemes to provide research grants to colleges and poorly funded universities have been in vogue for some time, although it may still be too early to detect any discernable influence of these approaches to promote interest in science in colleges. While interventions at college and university level are discussed and some experiments to catalyse change are in progress, the scenario at school level is much less widely discussed. Some questions that might be worth considering are: (1) Do we teach too much or too little science in school? (2) Do we teach the right subjects or are curricula fossilised over time? (3) Does the teaching of science, constrained by a rigid examination system, inhibit students from studying these subjects at college level? (4) Do teachers face constraints that are not factored in by bodies that impose syllabi?

In thinking about these questions I was drawn to a critique of the manner in which children study science: 'There is a disconnect at the heart of the … education system that is having a devastating effect on how and what children learn. Research shows that the most meaningful learning takes place when students are challenged to address an issue in depth which can only be done for a relatively small number of topics in any school year. But the traditional process of setting standards tends to promote a superficial "comprehensive coverage" of a field whether it be biology or history, leaving little room for in-depth learning. The curricula and textbooks that result are skin-deep and severely flawed.' Are these the words of an Indian commentator deeply concerned about school science education in India, where high school textbooks for the central school boards have now acquired formidable dimension? Indeed, some textbooks are so large and heavy that they seem more designed to improve weight lifting abilities rather than to kindle interest in apparently dry science subjects. Such books, often the product of a 'committee approach' to writing, leave teachers struggling to 'complete portions' before examinations. Curiously, the harsh assessment of curricula and textbooks refers to the school education system in the United States. The author, Bruce Alberts, is an eminent biologist, former President of the US National Academy of Sciences and currently editor of the journal *Science*. He is caustic when he says, 'the factoid-filled textbooks that most young US students are assigned for biology class make science seem like gibberish – an unending list of dry meaningless names and relationships to be memorized' (Alberts, B., *Science*, 2012, **338**, 1263). Reading this, I was relieved that nearly half a century ago the high school curriculum that I encountered contained little by way of science and seemed more focussed on history, literature, languages and geography, with mathematics standing alone. Large doses of facts and the importance of memorising science (rather like poetry) appeared in the college years, by which time choices had already been made and most escape routes closed.

The idea of a leaner curriculum advanced by Alberts may well be considered in India, where school textbooks have bloated to a level clearly designed to drive students away from science. Those who persist largely view school science as the passport to the 'professional' courses. Teachers may also welcome a reduction in the coverage of subjects like chemistry and biology which appear to be an unending collection of facts, presented in largely indigestible fashion. Teachers have little or no opportunities to participate in efforts to improve methods of science communication and to develop strategies for conveying, at least in part, the excitement that accompanies scientific discovery. Alberts notes that by the time students complete prescribed biology textbooks and the class based on them, 'it is clear they will know nothing of the kind of biology that inspires passion in the souls of scientists working in labs…'. If this is true in the United States, it is probably even more so in India, where curricula and examination systems leave little room for experimentation.

Teacher training, especially in the sciences and mathematics is an area of critical importance. While it is relatively easy to announce and formulate 'national missions' in the area of teacher education, implementation on the ground poses formidable logistical problems. Most importantly, there is a need to create a large cadre of 'trainers' who will undertake the task of teacher training. There is a great need to facilitate mechanisms by which school science teachers directly carry out modern experiments, eventually increasing the exposure of students to the role of experiments in science. There are wide variations in the quality of teachers in urban and rural schools and government and private schools. There are also considerable differences in the course content between state and central boards. Attempts to impose uniformity in standards have met with considerable reservation, if not outright hostility. While interventions at school level face many, apparently insurmountable obstacles, reforms in science courses at college and university level may be marginally easier to approach. A greater degree of autonomy in designing course content may be feasible at undergraduate level. Alberts argues that there is a 'need to replace the current "comprehensive" overviews of subjects with a series of in-depth explorations'. He suggests that this will require abandoning 'the one-size-fits-all textbooks… in favour of a large set of much shorter curriculum units, each designed to facilitate the active exploration of one important topic in depth for a month or so'. While Alberts' prescriptions are directed towards school education in the US, they may indeed be relevant for undergraduate courses in India, where early specialization and 'comprehensive coverage models' do not necessarily promote enthusiasm for science on a broad front.

The role of research project based learning in undergraduate science courses needs to be explored in India. This is nearly impossible within the framework of a three year program, but would be feasible in a four year course, bringing bachelor's degrees in science on par with the 'professional courses'. This is a model that has been frequently suggested but is only recently beginning to be implemented in isolated institutions. Experiments ongoing in the United States suggest that 'Inquiry Based Instruction' has proved very promising, promoting an interest in science well beyond the traditional classroom based instruction. Teams of undergraduates engaged in collective research projects learn 'skill sets necessary for scientists including communication, teamwork and the development of scientific ideas' (LaRue, C. C. and Padilla, P. A., *Science*, 2012, **338**, 487). The outcomes of experiments in research based learning are now being documented, with many examples where biology comes to life (Bascom-Slack, C. A. *et al.*, *Science*, 2012, **338**, 485). In a follow-up editorial, Alberts calls for a close collaboration between research scientists and teachers in developing 'new curriculum materials and teaching methods' that 'can help change the current trajectory of science education' (*Science*, 2012, **338**, 1396). If science courses are to be made attractive to students, scientists cannot sit on the sidelines and lament. They must actively engage, wherever possible, in experiments to transform science teaching in schools and colleges. Only the most highly talented can proclaim as Mark Twain did: 'Don't let schooling interfere with your education.'

P. Balaram