M.C. Mehta Vs Union of India: how is compulsory environmental education doing in India?

As a country with enormous biological resources and diversity, the relevance of compulsory environmental education at the school and college levels in India is unquestionable. The country houses 3 of the total 35 'global biodiversity hotspots'[1], and earns the recognition as a 'megadiverse' nation. Every citizen in India should be sensitized towards its rich biological diversity and assets, threats to this immense diversity and ways to conserve the natural wealth. Further, the country is laden with intense pollution problems of almost all kinds and severe disaster management concerns (like the recent Chennai floods). Haphazard urban and industrial development together with irresponsible public actions is the cause for severe water, air, soil and solid waste pollution in the country. The capital city of Delhi, for instance, is today considered the most polluted city in the world; some experts deem it to be even unfit for living. This calls for a meticulous environmental education programme in order to ensure responsible public behaviour towards addressing these concerns. Moreover, gradually escalating extreme and unpredictable weather events are issues which necessitate immediate public attention and awareness in the country. According to the petition titled M.C. Mehta Vs. Union of India, the Supreme Court of India gave various directions to the Central and State Governments for ensuring mandatory environmental education to students at the school and college level throughout the country[2,3]. Complying with this initiative, environmental education is now imparted compulsorily at the school and undergraduate (UG) level across India. But we wonder how successful and fruitful this initiative has been. Are we really able to imbibe pro-environmental behaviour among the students of this country? The answer to this question remains highly unsatisfactory. Our experiences, especially with the UG students, suggest an alarming trend with an omnipresent lack of sincere interest on the subject. The earnestness and dedication with which 'environmental science' is taught at the UG level raise inevitable questions. It seems that more than anything else, environmental education at the UG level is considered 'a mere ritual to be accomplished in order to get the desired degree'. Neither the teachers nor the students take up the subject seriously enough. The situation is both unfortunate and worrisome. In such a state of affairs, the true aim for the implementation of compulsory environmental education remains uncertain and unaccomplished. We argue that without pro-environmental behaviour and awareness among Indian citizens, no conservation effort will be entirely successful, no pollution abatement initiative will bear fruit, no recycling activity will reach its potential, no natural or manmade disaster events could be prevented (disaster mitigation measures remain a great challenge), no policy instruments could be satisfactorily implemented, and unplanned haphazard urban development will continue. Therefore, considering the current scenario of the country involving destruction of the environment in all possible dimensions, it is high time we realize the true significance of imparting environmental education at the school and college level. We argue that instead of making it just a passing paper, proper credits/marks should be allotted so that the subject gets its deserved attention from both the students and the teachers. Further, instead of a common syllabus of 'environmental science' for students of diverse disciplines, the curriculum could be made more innovative to attract the interest of the students according to their 'major subjects'. We believe that it will not be a mammoth task considering the evolution of sub-disciplines such as environmental history, environmental ethics, environmental sociology, environmental physics, environmental chemistry and environmental law, among several others. Field visits should be an integral part as 'environmental science' is anything but a subject to be learnt confined in a classroom. Let us educate properly and truthfully and learn to live in harmony with nature.

1. Marchese, C., *Global Ecol. Conserv.*, 2015, **3**, 297–309.
2. http://www.indiaenvironmentportal.org.in/files/environment%20education%20NGT%2017Jul2014.pdf
3. Roberts, N. S., *Environ. Educ. Res.*, 2009, **15**(4), 443–464.

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Make in India

The Guest Editorial by Arunan[1] brings attention to the subject of 'make in India' and how the scientific community should respond to it.

'Make in India' has actually been discussed in some form or other ever since we became independent. Viewed from a broad perspective, starting CSIR laboratories, DAE, DoS and several other institutions had similar underpinnings. They were embedded in a science policy framework wherein basic science was expected to feed into applied science, which in turn would generate technology for the welfare of the country. The needed balance between the three and the extent to which the goal has been achieved have been a matter of continuing debate.

If one interprets the term 'make in India' literally, it would not solve our problems at all. Ambassedor and Fiat cars are prime examples of 'make in India' frozen in time. Again and again we depended on imported technology. Those technologies were not absorbed and then used as input for improving the underlying technology. We stayed put. In the cases cited above, the private sector companies involved were either not aware of the nature of technological progress (which I find hard to believe), or were overwhelmed by short-term economic concerns. The net result was that these major automobile companies are nowhere near the top of the ladder today even in the national context. Korea is a good case study of how not to get into this kind of trap.

At the other end of the spectrum lies 'inventing the wheel' syndrome, wherein one wishes to make everything in India. In a highly interconnected world this does not make sense. The world today is qualitatively different from what it was in 1947. An intermediate path is that one buys what one can and makes what is difficult or impossible to get because of restrictive political reasons or lack of funds. My personal experience is that indigenously developed products cost substantially less than (roughly half of) the imported prize even if no monetary price is put against knowledge and experience gained in the process. To my knowledge, DAE and DoS have followed this trajectory and have been successful in their assigned missions. Both have generated the required science, technology and infrastructure indigenously at economically viable terms. (It is sometimes mentioned that there is no new science in these activities; in my view, this is a mistaken notion.) As a bonus, the overall training programme of DAE alone has produced more than 6000 highly trained scientists and engineers and many more technicians capable of collectively tackling any problem assigned to them. The problems include design and development of thermal as well as fast research and power reactors, atomic weapons (note 1), a variety of particle accelerators, world class scientific instruments used at international laboratories like CERN, Geneva and ISIS pulsed neutron source, UK, many special materials, irradiators for cancer treatments and food preservation, medical and industrial isotopes, new varieties of pulses and grains, etc. I reckon a similar level of contribution from DoS. Both have succeeded in establishing a variety of industries (Antrix, NPCIL, ECIL, NFC, ACTREC, and many others) based on developments within the system. DAE has transferred more than a 100 technologies to private enterprises. A separate note would be needed to discuss their impact. Positive aspects of these two examples should be taken into consideration when one thinks of 'make in India'.

The 'make in India' model described above starts with a large core vision and develops it in its entirety, including the necessary science, technology, infrastructure, commerce and the rest. This model is probably not suited for many 'individual' efforts.

Results of some successful 'individual' efforts (Pradip K. Ghosh, R. Srinivasan, K. P. J. Reddy), not yet scaled up, have been mentioned in the Guest Editorial[1]. The number of such efforts on a pan-India basis is actually very large and requires careful consideration. Some of them are local in character and could be difficult to scale up. Those that can be scaled up require institutional support and formal encouragement. They require special attention of science administrators and social scientists. I am not well informed on this, but feel that one could learn from the green revolution and white revolution. Both required extensive social interaction and networking at the grass roots level. Innovations like solar lanterns, integrated gobar-gas based development of villages, utilization of toilets in village homes and many others fall in this category.

There is a general tendency to worry about Indians not having won a Nobel Prize for science done in India after independence (note 2). Without in any way bringing down the respect shown to the Nobel Prize, I would like to humbly express that I am not able to appreciate our excessive concern with it. Instead, we ought to take inspiration from dedication of well-known Indians, including Mahatma Gandhi, S. N. Bose, J. C. Bose, G. N. Ramachandran and others, who did not get it. Men like Homi Bhabha, Vikram Sarabhai and M. S. Swaminathan have contributed so much to the growth of modern S&T in India and to bring science-based benefits to the country that any award is too small for them.

Another obsession of our academics is with respect to the number of publications and this comes as an obstacle to 'make in India'. Endeavours which will not fetch publications and Ph D for the students are carefully avoided. Commitment is often more to publication than to science. As a result they have, by and large, not ventured into large-scale projects and creation of sophisticated instruments which have entered into the very life and guts of modern science, as was pointed out by Balaram[2]. No wonder our science is largely publications and very little 'make in India'. There is a need for balance here. Hopefully with the new policy on innovation and emphasis on 'make in India', due weightage will now be given to personnel involved in such activities.

Continuing on a similar theme, the Guest Editorial[1] mentions that building a synchrotron 'appears to have been shelved for now'. Arunan asks, 'why seven decades after independence, we are not able to support, plan and build a synchrotron?' This is actually three questions in one, namely, (a) support (b) plan and (c) build. As I have some background with the use of synchrotrons and designing beam lines and experimental stations, I seek indulgence to make some remarks here. This idea to establish a new electron synchrotron better than Indus-2 is almost a decade old. The proposal was made partly due to the fact that the Indus-2 under construction at that time by the DAE was getting delayed and some protein crystallographers were quite uncomfortable about this. After considerable amount of background work, the group of scientists perusing this idea was asked by the Department of Science and Technology to prepare a project report in 2010. I have not seen this report and its cost and time estimates. So I shall make some general remarks. Typically such machines with the accompanying beam lines and experimental stations could take 6–10 years to build from the ground-breaking day anywhere in the world. So even assuming the unlikely event of the project starting soon (?), it would be fair to assume that the new machine will be available only after 2025. A ballpark figure for the cost of a 3 GeV machine with beam lines and instruments is in the vicinity of Rs 5000 crores plus/minus 30% depending on the specifications and how the 'make in India' concept is factored into this proposal. It can be built only by full collaboration between machine as well as instrument designers and builders, and users if one accepts a buy-plus-build model.

In the meantime the 2.5 GeV Indus-2 with more than half a dozen beams and

450 MeV Indus-1 with its beam lines are functioning. Users of synchrotron radiation should fully use both Indus-1 and Indus-2, and compete for beam time at other better synchrotron sources. Experimental facilities at the Indus machines have been built for all scientists in India. They may not match always with the best, but let it also be said without doubt that the best is never available off the shelf. They have tremendous capacity to produce original and high-quality science; their utilization must be maximized by scientists from outside DAE laboratories. The case for a better machine is strong. Equally strong is the need to creat a large enough community of users through full utilization of existing machines. Finally, there is a compelling requirement for all concerned to put their heads together.

Notes

1. The controlled nuclear explosions of 1974 and 1998 were a joint effort of the DAE and defence establishments, and not only of the latter as mentioned in the Guest Editorial. DAE started the initiative and took responsibility of the nuclear part; defence establishments took care of the conventional weapons technology, and the two worked as a single team. Equally important was the policy decisions of the existing governments. Tenzing Norgey and Edmund Hillary never revealed who stepped first on Mount Everest; it was their joint effort.
2. A comparison with the Republic of China with more than three times the Indian budget for S&T is illuminating.

1. Arunan, E., *Curr. Sci.*, 2015, **109**, 1519–1520.
2. Balaram, P., *Curr. Sci.*, 2000, **78**, 365–366; 2012, **102**, 1241–1242.

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Response:

I thank Dasannacharya for his comments and in particular for pointing out that the nuclear explosions carried out in 1974 and 1998 were both joint efforts of DAE and defence establishments. I take this opportunity to include the comments by Pradip K. Ghosh, who had also pointed out some technical corrections: ‘There is a bit of technical “shortcoming” when you say that we wished *to build* the world’s highest resolution optical spectrometer (because that was not the objective) – we *actually built* (to serve our research purpose) what we believe was *this country’s* highest resolution highest dispersion (dual dispersion) visible – UV scanning spectrometer (total 21 ft: the front part 7 ft, the rear part 14 ft). The resolution was limited by the grating used. By changing the grating in the same structure, the resolution could be increased. I do not know where that would fit in Ottawa NRC’s collection, but ours was a fine one in operation. But this “shortcoming” in no way matters on what you have said in the body of your write-up.’

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Is the Scyphozoan jellyfish *Lychnorhiza malayensis* symbiotically associated with the crucifix crab *Charybdis feriatus*?

Scyphozoan jellyfish (Medusae), the gelatinous invertebrate group, plays a vital role in the global oceanic and coastal ecosystems. By virtue of their floating nature, and horizontal and vertical spread in the water column, they are known to have varied associations with other invertebrates and teleosts, which make them an integral part of the marine ecosystem. In general, studies on ecology and trophic links of jellyfish from Indian waters are scanty.

Regular research cruises ($n = 45$) in 2014 conducted by the Central Marine Fisheries Research Institute, Kochi, onboard *FRV Silver Pompano*, the Scyphozoan Rhizostomeae jellyfish *Lychnorhiza malayensis* were caught in the experimental trawl catches. *L. malayensis* has a wide distribution in the Malayan Archipelago and the Indian Ocean. During the last century, Nair[1] has reported the presence of this species off the Thiruvananthapuram coast (Kerala) for a short period, from September to October during 1942 and 1943. In the present study, distribution range of *L. malayensis* was found to be extended from Thiruvananthapuram to Goa, inhabiting the depth zone 6–50 m and the period of occurrence was also prolonged from July to October. Jellyfish sampled ($n = 468$) were examined for identifying the associated animals attached to the body of these jellyfish. They were caught in large numbers in 16 hauls; the crucifix crab *Charybdis feriatus* was found to have a close facultative commensalism with these jellyfish.

The associations of jellyfish species with brachyuran crabs in global oceans have been reviewed[2] as well as those with fishes[3]. However, the symbiotic association of *L. malayensis* with *C. feriatus* has not been reported earlier. *C. feriatus* was found associated with ($n = 65$) jellyfish. These associations were noticed only from August to October, with maximum in September.

C. feriatus associations were observed in the jellyfishes which were caught in 12–18 m depth. The bell diameter (BD) and wet weight of the jellyfish were measured. BD of *L. malayensis* ranged from 11 to 33 cm and wet weight from 150 to 1250 g. The crabs were found clinging onto the oral arms (tentacles) of the jellyfish (Figure 1). Correlation between the association of crabs with size and weight of the jellyfish could not be established. Most of the jellyfish harboured single adult specimen of *C. feriatus*, while few had two crabs. The