

How Pakistan can develop a culture of science

by

Pervez Hoodbhoy

School syllabi demand it, but even so few young Pakistanis want to study science subjects and still fewer want to become scientists. Many generations have found science so odiously dull that they are now indifferent – even hostile – to a subject that stands at the very pinnacle of human understanding and progress. While some of our better students will be reasonably successful in science-related professions such as engineering, medicine, and information technology, their poor science backgrounds will leave them ill-equipped for pushing the frontiers of these rapidly evolving fields.

Contrast this with India. Surveys show that school students see science as the most prestigious and glamorous career to pursue. For them Einstein, Stephen Hawking, black holes, genes, etc. is the way to go. Although most eventually opt for more “normal” professions, yet sufficient numbers persist and some eventually rank among the world’s better scientists. This has been key to India’s emergence as a world power.

Why study science?

Across the world, science is taught in schools for an excellent reason – we owe pretty much the entire modern world to it. The prosperity of nations and individuals is contingent upon our ability to understand, apply, monitor and, when necessary, control science. Take the products of science away and we would return to the dark days of our ancestors when a child at birth was more likely to die than live.

There is another excellent reason to study science. Far from being a cold and soulless collection of facts, it is a delicate and beautiful human pursuit imbued with principles that are amazingly simple and precise. At the same time, scientific principles are incredibly powerful and universal. Exactly the same laws explain why the universe is expanding, stars shine, the sky is the colour blue, human hearts beat and birds fly. Science engages the imagination and fascinates endlessly.

But science is more than gadgets and processes. It is even more than a beautiful and elegant terse description of nature. Fundamentally, science provides a way to comprehend reality in ways that enable truth to be approached incrementally through a rigorous step-by-step process. Science insists on relentless questioning and testing of assumptions, using both logic and empirical verification.

The nature of science, which I have tried to describe above, also makes it the weapon of choice for combating the madness of fundamentalism that is now sweeping the globe. Science is a lethal antidote for every kind of dogma and fundamentalism. Consequently, it is deeply feared by the orthodox.

To appreciate this, let us revisit the epic trial of Galileo. It was not a question of cosmology or physics that worked the papacy into a hangman’s frenzy. The church could not really have cared whether the sun goes around the earth or vice-versa. Crucially important, however, was that the word of god stood in danger of being shown up. If, heaven forbid, the Earth actually encircled the sun, the Bible would be proven wrong, suggesting that its authors would have flunked freshman physics. This would have placed into jeopardy the entire text of the Bible, including all miracles. All the glorious stories of Joshua and Gideon – which good Christians must accept without question – would have been placed in doubt. Science, which nags constantly for empirical proof

and obsessively asks for reasons, was simply too annoying – and threatening – to be tolerated or even ignored by the 17th century Catholic church.

In more recent times, archaeological science repudiates the fanatics of the Vishwa Hindu Parishad who in 1992 instigated bloody riots in India after pulling down a 400-year-old Babri mosque, claiming that the god Ram had been born in a temple that had once existed in the same place. A recent example related by the Indian writer, Praveen Swami: early in March 2012, little drops of water began to drip from the feet of the statue of Jesus nailed to the cross on the church of Our Lady of Velankanni, down on to Mumbai's unlovely Irla Road. Hundreds began to flock to the church to collect the holy water in little plastic bottles, hoping the tears of the “son of god” would sanctify their homes and heal their beloved. Sanal Edamaruku, the eminent rationalist thinker, arrived at the church a fortnight after the miracle began drawing crowds. It took him less than half an hour to discover the source of the divine tears: a filthy puddle formed by a blocked drain, from where water was being pushed up through a phenomenon all high-school physics students are familiar with, called capillary action.

Molecular biology and genetic science have made nonsense of creationism and intelligent design, cherished by Christian fundamentalists in the United States who continue to mount a relentless campaign to include in school curriculums their faith-based views of how the earth and its living organisms came to be. Some extremist Jewish groups also derive additional political strength from antiscience movements. For example, certain American cattle tycoons have for years been working with Israeli counterparts to try to breed a pure red heifer in Israel, which, by their interpretation of chapter 19 of the Book of Numbers, will signal the coming of the building of the Third Temple, an event that would ignite the Middle East.

Why our science teaching is so bad

I have argued above that some anti-science currents exist in many countries including America, India, and Israel. Fortunately for them, these are side-currents and those people who believe in combining religion with science are considered “crackpots” in those countries. This has allowed a genuine science to flourish, both with regard to research and teaching.

Pakistan, unfortunately, is not doing well at all in science. Here we have many crackpots in the mainstream. In terms of new discoveries and inventions, Pakistan scarcely appears on the scientific map of the world. To understand the difference from scientifically successful countries is very important. Where should one begin?

As in many other developing countries, the dead hand of tradition blocks progress. The Pakistani educational system, shaped by traditional social and cultural values, discourages questioning and stresses obedience. This means that scientific thinking is difficult to develop and nurture.

Tyranny of the teacher lies at the core. In Urdu we say that the teacher is not just a teacher, he is your father. Since a father is all-wise, he dare not be questioned. Instead of experiencing science as a personally fulfilling quest for understanding, under the watchful eyes of despotic teachers, students memorize an arbitrary set of rules and an endless number of facts. X is true and Y is false because that is what the textbook says. (I grind my teeth whenever a master’s student in my university class gives me this argument! But this is this is the inevitable consequence of authoritarianism.) The mindset needed for authentic science is alien to the educational environment of schools, colleges, and universities in countries such as Pakistan.

How can countries that remain mired in such a thought-deadening process of education develop a true scientific mindset?

The first thing that must be stated is that to begin the effort in colleges and universities is to begin too late. Change must be instituted at the primary school level. Good science pedagogy requires deliberate inculcation of the spirit of healthy questioning in the classroom among five- and 10-year-old children not just 20 year-old young adults.

Correct attitudes start developing naturally when students encounter questions that engage their mind rather than test their memory. For this, it is important to begin with tangible things. One does not need a doctorate in cognitive studies to know that young people learn best when they deal with visual, auditory, tactile, and kinesthetic objects. As their experience grows, they learn to understand abstract concepts, manipulate symbols, reason logically, solve theorems, and generalize. These abilities are destroyed, or left woefully undeveloped by rote memorization.

It should therefore be normal practice for teachers to raise such questions as: How do we know and learn? What is important to measure? How can we confirm our measurements and conclusions? What evidence has been brought to bear on the question? How can we make sense out of the results? Is there a counter explanation, or perhaps a simpler one? The aim should be to get students into the habit of posing such questions and then framing answers.

Bad textbooks

Locally authored science textbooks, in my opinion, should be banned because they are a serious impediment in the development of a scientific culture. Although a dysfunctional examination system and bad science teachers are also blameworthy, poor textbooks are especially debilitating in a culture where the written word is considered virtually unchallengeable.

Over the years, I have collected many titles, both Urdu and English. The Urdu ones are even more unattractive than their English counterparts. All were produced by the Punjab and Sind textbook boards. The number of printed books must now run into many hundreds of millions.

The books reflect an attitude that science is to be taught no differently from geography or history. A stern looking Quaid-e-Azam on the inside of every front cover admonishes students to study else “we may be wiped out altogether”. But threats – or exhortations that learning is a holy duty for improving our chances in the Hereafter – are useless. They cannot create interest in a subject that springs from human curiosity.

Local books seem designed to kill curiosity rather than nurture it. Mathematics is reduced to a set of drills shorn of relevance and meaning while physics, chemistry and biology are just about remembering formulae and diagrams. Whether written from scratch, or with bits cut and pasted from here or there, these books give no hint that knowledge is being continuously created by human endeavor and intelligence.

Bad pedagogy is all over. For example, a terrible way of teaching about surface tension is to begin with “surface tension comes because a skin is created on the surface of a liquid by attraction of molecules”. Now, no one has ever seen a molecule with a naked eye, much less seen one attracting the other. A student who learns it this way has not learnt anything at all.

On the other hand, a good approach would be to ask the student to gently place a razor blade on the still surface of water. Why does it float? The student is then allowed to deduce that there is some kind of invisible skin; a drop of liquid soap thins it further and the blade sinks. In this manner the student could be led towards meaningful comprehension of phenomena through a logical process.

The weakest parts of the books I have browsed through are the chapter-end questions and exercises. This is useless memory-recall drill. The authors do not know that the essence of science is problem solving, and that good scientific training builds a student's capacity to internalize newly learnt principles by applying them to problems whose answers are yet unknown. In contrast, foreign-authored "O" level books – used only by a tiny sliver of up-scale Pakistani schools – usually do have good questions.

There is only a little good news. Compared to earlier textbooks, newer ones have fewer conceptual and spelling mistakes. Also, with time, better printing and use of color illustrations are more common. But, as before, a jumble of facts bundled together cannot spark the imagination of young minds.

Some say that money lies at the root of the problem. Indeed, authoring textbooks is a lucrative business because of the sheer volume of books sold. The pressure to include incompetent authors – and to share profits – is enormous. This is probably why the current class-10 mathematics book of the Punjab Textbook Board, has six authors and the slim 187-page class-10 chemistry book has eight authors! So, while every individual gets a cut from the sales, the blame can be easily passed on to others.

I doubt that stricter regulations can help. Local textbooks are such poor pedagogical instruments for a very good reason: science is not part of Pakistan's national culture. There is endless political entertainment on TV but no locally produced science programs. I know of no science museums except for one in Lahore. So great is the public's ignorance of science that the path-breaking work of Abdus Salam is considered inferior to the copy-cat reverse engineering that led Pakistan to the bomb.

There is a solution: good science books exist. So use them! Elite "O" level schools use books chosen from the most successful ones published internationally. Surely matric-level schools can be made to do the same after the books are properly adapted/translated. Should a Pakistani be the author (or among the authors), so much the better! But quality alone should matter, not where the author comes from.

Unfortunately, nationalist bravado kicks in whenever this is proposed. The rhetoric is that Pakistanis can author science textbooks just as well as anyone else. The conclusion is that we should not rely upon foreign educational materials. But an inflated national ego, together with small scientific accomplishment, is hardly helpful.

Firm resolve is needed to turn the situation around. Pakistanis must admit locally written textbooks are nowhere as good as foreign ones, and decide to use the very best ones available anywhere. The argument against importation is senseless because we use medicines and computers invented by outsiders, fly in their planes, and use their mobile phones. False pride and misplaced beliefs must be set aside. Eating humble pie is never easy, but surely this is a small price to pay for having scientifically smart Pakistanis in the future.

The Way Forward

Bad science teaching in Pakistani schools and widespread scientific illiteracy has made the siren song of unreason ever more sonorous and attractive. In older times, only the ignorant and illiterate accepted the idiocy of the aamils, pirs, mullahs and assorted soothsayers and charlatans. Today, however, even college graduates and the rich and powerful, calmly accept and embrace nonsense. To them it is high wisdom.

Good science education can help change this. In fact, the demons of superstition and narrow-mindedness can only be chased away by those who know and understand the spirit of science.

Though difficult, the situation in Pakistan is by no means hopeless. Let me give one personal example that shows that, bucking the mind-deadening ‘education’ in schools, Pakistani kids are still curious. Inspired by the world-renowned scientists Carl Sagan (of *Cosmos* fame), some time ago I created and presented a series of popular science programmes for Pakistani television. The response was phenomenal. I received thousands of letters, many from young students living in remote villages. Dozens of young people personally came to my department: I even had an unannounced visit by the entire student body from a remote village school in southern Punjab!

Science cuts across every boundary – cultural, political, social, and even psychological. The only way to get a handle on many of today’s conflicts is to enable people to learn to think more scientifically and to encourage them to move away from the various fundamentalisms derived from religion, nationalism and other exclusivist ideologies that create impenetrable, yet false, boundaries between me and you, and us and them.

The message of science is that we are one human family. The process of science proves that the only way to effectively deliver this message is through clear and rational thinking that has been nurtured through good education and challenging and rewarding experience. Money counts in achieving this humanistic goal. But mindsets count much more.

The author received his doctorate in nuclear physics from MIT, and undergraduate degrees in electrical engineering, mathematics, and physics also from MIT. He taught at Quaid-e-Azam University for 38 years and now teaches at LUMS.