NCF 2005: SCIENCE*

One important human response to the wonder and awe of nature from the earliest times has been to observe the physical and biological environment carefully, look for any meaningful patterns and relations, make and use new tools to interact with nature, and build conceptual models to understand the world. This human endeavour has led to modern science. Broadly speaking, the scientific method involves several interconnected steps: observation, looking for regularities and patterns, making hypotheses, devising qualitative or mathematical models, deducing their consequences, verification or falsification of theories through observations and controlled experiments, and thus arriving at the principles, theories and laws governing the natural world. The laws of science are never viewed as fixed eternal truths. Even the most established and universal laws of science are always regarded as provisional, subject to modification in the light of new observations, experiments and analyses.

Science is a dynamic, expanding body of knowledge, covering ever-new domains of experience. In a progressive forward-looking society, science can play a truly liberating role, helping people escape from the vicious cycle of poverty, ignorance and superstition. The advances in science and technology have transformed traditional fields of work such as agriculture and industry, and led to the emergence of wholly new fields of work. People today are faced with an increasingly fast-changing world where the most important skills are flexibility, innovation and creativity. These different imperatives have to be kept in mind in shaping science education.

Good science education is true to the child, true to life and true to science. This simple observation leads to the following basic criteria of validity of a science curriculum:

1. ***Cognitive validity*** requires that the content, process, language and pedagogical practices of the curriculum are age appropriate, and within the cognitive reach of the child.
2. ***Content validity*** requires that the curriculum must convey significant and correct scientific information. Simplification of content, which is necessary for adapting the curriculum to the cognitive level of the learner, must not be so trivialised as to convey something basically flawed and/or meaningless.
3. ***Process validity*** requires that the curriculum should engage the learner in acquiring the methods and processes that lead to the generation and validation of scientific knowledge and nurture the natural curiosity and creativity of the child in science. Process validity is an important criterion since it helps the student in 'learning to learn' science.

*[Source: www.ncert.nic.in]

Asking questions

"Air is everywhere" is a statement that every schoolchild learns. Students may know that the earth's atmosphere consists of several gases, or that there is no air on the moon. We might be happy that they know some science. But consider this exchange in a Class IV classroom.

Teacher: Is there air in this glass?

Students (in chorus): Yes!

The teacher was not satisfied with the usual general statement, "Air is everywhere." She asked the students to apply the idea in a simple situation, and found, unexpectedly, that they had formed some "alternative conceptions".

Teacher: Now I turn the glass upside down. Is there still air in it?

Some students said "yes", others said "no", still others were undecided.

Student 1: The air came out of the glass!

Student 2: There was no air in the glass.

In Class II, the teacher put an empty glass over a burning candle and the candle went out!

The students had performed an activity whose memory had remained vivid even two years later, but some of them at least had taken away an incorrect conclusion from it.

After some explanation, the teacher questioned the students further. Is there air in this closed cupboard? Is there air in the soil? In water? Inside our body? Inside our bones? Each of these questions brought up new ideas and presented an opportunity to clear some misunderstandings. This lesson was also a message to the class: do not accept statements uncritically. Ask questions. You may not find all the answers but you will learn more.

What biology do students know?

"These students don't understand science. They come from a deprived background!" We frequently hear such opinions expressed about children from rural or tribal backgrounds. Yet consider what these children know from everyday experience.

Janabai lives in a small hamlet in the Sahyadri hills. She helps her parents in their seasonal work of rice and tuar farming. She sometimes accompanies her brother in taking the goats to graze in the bush. She has helped in bringing up her younger sister. Nowadays she walks 8 km. every day to attend the nearest secondary school.

Janabai maintains intimate links with her natural environment. She has used different plants as sources of food, medicine, fuelwood, dyes and building materials; she has observed parts of different plants used for household purposes, in religious rituals and in celebrating festivals. She recognises minute differences between trees, and notices seasonal changes based on shape, size, distribution of leaves and flowers, smells and textures. She can identify about a hundred different types of plants around her — many times more than her Biology teacher can — the same teacher who believes Janabai is a poor student.

Can we help Janabai translate her rich understanding into formal concepts of Biology? Can we convince her that school Biology is not about some abstract world coded in long texts and difficult language. Rather it is about the farm she works on, the animals she knows and takes care of, the woods that she walks through every day. Only then will she truly learn science.

4. ***Historical validity*** requires that the science curriculum be informed by a historical perspective, enabling the learner to appreciate how the concepts of science evolve over time. It also helps the learner to view science as a social enterprise and to understand how social factors influence the development of science.
5. ***Environmental validity*** requires that science beplaced in the wider context of the learner's environment, local and global, enabling him/her to appreciate the issues at the interface of science, technology and society, and equipping him/her with the requisite knowledge and skills to enter the world of work.
6. ***Ethical validity*** requires that the curriculum promote the values of honesty, objectivity, cooperation, and freedom from fear and prejudice, and inculcate in the learner a concern for life and preservation of the environment.

3.3.1 The Curriculum at different Stages

Consistent with the criteria given above, the objectives, content, pedagogy and assessment for different stages of the curriculum are summarised below:

At the primary stage, the child should be engaged in joyfully exploring the world around and harmonising with it. The objectives at this stage are to nurture the curiosity of the child about the world (natural environment, artifacts and people), to have the child engage in exploratory and hands-on activities for acquiring the basic cognitive and psychomotor skills through observation, classification, inference, etc.; to emphasise design and fabrication, estimation and measurement as a prelude to the development of technological and quantitative skills at later stages; and to develop basic language skills: speaking, reading and writing not only for science but also through science. Science and social science should be integrated as 'environmental studies' as at present, with health as an important component. Throughout the primary stage, there should be no formal periodic tests, no awarding of grades or marks, and no detention.

At the upper primary stage, the child should be engaged in learning the principles of science through familiar experiences, working with hands to design simple technological units and modules (e.g. designing and making a working model of a windmill to lift weights) and continuing to learn more about the environment and health, including reproductive and sexual health, through activities and surveys. Scientific concepts are to be arrived at mainly from activities and experiments. Science content at this stage is not to be regarded as a diluted version of secondary school science. Group activities, discussions with peers and teachers, surveys, organisation of data and their display through exhibitions, etc. in schools and the neighbourhood should be important components of pedagogy. There should be continuous as well as periodic assessment (unit tests, term-end tests). The system of 'direct' grades should be adopted. There should be no detention. Every child who attends eight years of school should be eligible to enter Class IX.

At the secondary stage, students should be engaged in learning science as a composite discipline, in working with hands and tools to design more advanced technological modules than at the upper primary stage, and in activities and analyses on issues concerning the environment and health, including reproductive and sexual health. Systematic experimentation as a tool to discover/verify theoretical principles, and working on locally significant projects involving science and technology, are to be important parts of the curriculum at this stage.

At the higher secondary stage, science should be introduced as separate disciplines, with emphasis on experiments/ technology and problem solving. The current two streams, academic and vocational, being pursued as per NPE-1986, may require a fresh look in the present scenario. Students may be given the option of choosing the subjects of their interest freely, though it may not be feasible to offer all the different subjects in every school. The curriculum load should be rationalised to avoid the steep gradient between secondary and higher secondary syllabi. At this stage, the core topics of a discipline, taking into account recent advances in the field, should be identified carefully and treated with appropriate rigour and depth. The tendency to cover a large number of topics of the discipline superficially should be avoided.

3.3.2 Outlook

Looking at the complex scenario of science education in India, three issues stand out clearly. First, science education is still far from achieving the goal of equity enshrined in our Constitution. Second, science education in India, even at its best, develops competence but does not encourage inventiveness and creativity. Third, the overpowering examination system is basic to most, if not all, the fundamental problems of science education in India.

The science curriculum must be used as an instrument for achieving social change in order to reduce the divide based on economic class, gender, caste, religion and region. We must use textbooks as one of the primary instruments for equity, since for a great majority of school-going children, as also for their teachers, it is the only accessible and affordable resource for education. We must encourage alternative textbook writing in the country within the broad guidelines laid down by the National Curriculum Framework. These textbooks should incorporate activities, observation and experimentation, and encourage an active approach to science, connecting it with the world around the child, rather than information-based learning. Additionally, materials such as workbooks, cocurricular and popular science books, and children's encyclopaedia would enhance children's access to information and ideas that need not go into the textbook, loading it further, but would enrich learning that takes place through project work. There is a dearth of such materials with rich visuals in regional languages.

The development of science corners, and providing access to science experimentation kits and laboratories, in rural areas are also important ways of equitably provisioning for science learning. Information and Communication Technology (ICT) is an important tool for bridging social divides. ICT should be used in such a way that it becomes an opportunity equaliser by providing information, communication and computing resources in remote areas. ICT if used for connecting children and teachers with scientists working in universities and research institutions would also help in demystifying scientists and their work.

For any qualitative change from the present situation, science education in India must undergo a paradigm shift. Rote learning should be discouraged. Inquiry skills should be supported and strengthened by language, design and quantitative skills. Schools should place much greater emphasis on co-curricular and extra-curricular activities aimed at stimulating investigative ability, inventiveness and creativity, even if these are not part of the external examination system. There should be a massive expansion of such activities along the lines of the Children's Science Congress, being held successfully at present. A large-scale science and technology fair at the national level (with feeder fairs at cluster/district/state levels) may be organised to encourage schools and teachers to participate in this movement. Such a movement should gradually spread to every corner of India and even across South Asia, unleashing a wave of creativity and scientific temper among young students and their teachers.

Examination reform should be initiated as a national mission, supported by adequate funding and high-quality human resources. The mission should bring teachers, educationists and scientists on a common platform; launch new ways of testing students that would reduce the high level of examination-related stress; curb the maddening multiplicity of entrance examinations; and undertake research on ways of testing multiple abilities other than formal scholastic competence.

These reforms, however, fundamentally need the overarching reform of teacher empowerment. No reform, however well motivated and well planned, can succeed unless a majority of teachers feel empowered to put it in practice. With active teacher participation, the reforms suggested above could have a cascading effect on all stages of science teaching in our schools.