Aerum Khan
aerumkhan.ciet@gmail.com

Science, Scientific Literacy and Scientific Temper in the Curricular Documents

Abstract

Developing a scientifically literate population is a significant challenge and one of the most important objectives of Science education at school level in India as well as globally. Only a scientifically literate person can be rational, logical, and critical in her approach for making decisions and solving problems of daily life. The spirit of inquiry and the acceptance of the right to question and be questioned are fundamental to Scientific Temper. This research article attempts to review different curricular documents developed post-independence which have shown the path to the role of Science as a subject in general and scientific temper and scientific literacy in particular.

Introduction

Science in the modern world occupies a central place in the basic curriculum. A spirit of enquiry, an attitude of rationality, an itch for experimentation, etc. which are the essence of scientific temper, have to be inculcated with regard to every activity (Nayar, 1989). The ideas expressed by D.P. Nayar fully reflect the importance of Science in the curriculum. The attributes developed in an individual can be characterised to a better extent as scientific literacy and later on scientific temper.

The first efforts to communicate the so called modern western scientific ideas to the Indian public was made during the second half of the 19th Century. Small 'science societies' developed in various parts of India. Parallels could be drawn between what happened in Europe in the 17th and 18th Centuries and the efforts to disseminate Science in India in the latter part of 19th and the first half of 20th century. It is obvious that in India the number of people involved in Science related activities at that time was quite limited, and no serious effort was made to bring them together into a large scale 'Science movement'. Although the Indian freedom movement also operated as a carrier of modern scientific ideas (Raza, Singh, Kumar, Nayak, 2008).

Almost all the political leaders of Indian freedom movement and social reformers repeatedly emphasised the need to integrate modern Science into Indian culture. In 1937 Gandhiji emphasised the need of Science in Nai Taleem (New Education), he writes:

'Only every handicraft has to be taught not merely mechanically as is done today, but scientifically….'

(M.K. Gandhi, *Harijan*, 31 July 1937)

India got freedom from British rule in 1947, this was followed by the plans of the emerging ruling class and politicos to build a modern industrialised India. They recognised the need for a wider acceptance of scientific ideas in society. After this phrases like 'scientific temper', 'scientific belief system', broad scientific outlook' and 'scientific method' began to echo in various public forums.

The Freedom movement, though primarily political in nature, at times, operated as the carrier of modern scientific ideas. Serious efforts both at the level of the Government machinery and by the non-governmental organisations had to wait for the imminent Independence from the British Imperialism.

The dream of building a modern and industrialised India conceived by the leadership of the freedom struggle required technical manpower to be trained within the country in large numbers. A wider acceptance of scientific ideas in the society was a necessary precondition for achieving the goals that the leadership had set before the new born Independent India. Phrases such as 'scientific temper' 'broad scientific outlook', 'scientific belief system' and 'scientific method' echoed repeatedly in various forums of debate. Newspapers, magazines and electronic medium (television network did not exist at that time) began to be used for the dissemination of scientific information.

In the latter half of the fifties a large number of new books for teaching science in regional languages were written. The number of popular books on various topics of science and related subjects swelled. Translating English texts posed two major problems, one that Indian languages culturally had a limited capability of expressing modern scientific ideas and secondly, there was an acute shortage of standard technical terms. These terms had to be coined, at times this was done mechanically and at others, recourse was taken to using familiar but inaccurate terms leading to obfuscation or in some cases incorporation of 'anglicised' terms into the local languages (Raza, Singh, Kumar, Nayak, 2008).

Scientific Literacy and its Etymology

One of the primary goals of Science education can be summed up as development of scientific literacy in the individuals. Scientific Literacy (SL) is the ability of individuals to live satisfactorily and conveniently in a techno-Science culture. A literate population is equally imperative, but scientific literacy is a significant subset of literacy. A high scientific literacy rate is important for today's technologically driven society particularly for a nation that is among the fastest growing economies with a rapidly burgeoning population, the majority of it concentrated in villages and remote areas. In simple terms scientific literacy implies the ability of a person to ask questions, determine answers to questions derived from everyday experiences. It is the ability to seek explanations to natural phenomena instead of merely accepting given statements or considering them to be miracles. A scientifically literate person should be able to take informed decisions; and take positions that are scientifically and technologically informed. Such a person understands scientific concepts and processes required for the participation in society and economic productivity. The term 'scientific literacy' also refers to understanding of science to contribute to public debate of socio-scientific issues and to make informed decisions on these issues, as well as the appreciation of processes, values and ethics related to science (Dawson & Venville, 2009).

Scientific Temper and its Etymology

The Scientific temper needs to be a way of life for individuals and societies. It uses the scientific method which includes questioning, observing physical reality, testing, hypothesizing, analysing, and

communicating (not necessarily in that order). "Scientific temper" describes an attitude which involves the application of logic. Discussion, argument and analysis are vital parts of scientific temper. Elements of fairness, equality and democracy are built into it (The Hindu, 2005).

In 1946 Pandit Jawaharlal Nehru used the phrase 'scientific temper'. He introduced and defined the phrase 'scientific temper' in his book *Discovery of India*, and also popularised it by repeatedly using it in his speeches. According to him, the scientific approach, the adventurous and yet critical temper of science, the search for truth and new knowledge, the refusal to accept anything without testing and trial, the capacity to change previous conclusions in the face of new evidence, the reliance on observed fact and not on pre-conceived theory, the hard discipline of the mind is very much needed. All the above points are necessary, not merely for the application of science but for life itself and the solution of its many problems (Nehru 1946).

The genesis and development of the idea of the scientific temper is connected to ideas expressed earlier by Charles Darwin, in his words:

"[F]reedom of thought is best promoted by the gradual illumination of men's minds, which follows from the advance of science."

Charles Darwin

The spirit of inquiry and the acceptance of the right to question and be questioned are fundamental to Scientific Temper. It calls upon one to ask the 'how', the 'what', and the 'why' of an object, event or phenomenon. It further calls upon one to exercise the right to question, provided of course, the questioning of an existing theory, hypothesis or statement or social situation is done in accordance with the scientific method and is not merely a bare assertion of one's belief (Haksar, P.N., Ramanna, R. and Bhargava, P.M. (1981).

Notably during the 42nd Constitutional Ammendment Act, 1976 for the Indian Constitution an Article 51A was inserted, which makes provisions for the fundamental duties prescribed for citizens of India. This Article has a point which declares the role of Scientific temper in the following way: "It shall be the duty of every citizen of India to develop the scientific temper, humanism and the spirit of inquiry and reform." (Article 51A, The Constitution of India)

Statement on Scientific Temper, 1981

The Nehru Centre, Bombay issued a document titled 'A Statement on Scientific Temper' on 19 July 1981, which was signed by a group of eminent intellectuals, scientists and academicians. P.N. Haksar hoped that the statement would succeed in generating a nationwide discussion and also '[G]enerate a movement for the much needed second renaissance' in the country (Statement on Scientific Temper, 1992:185) (Mahanti, 2013).

The Statement articulated a notion of scientific temper at the heart of which was the method of science. The scientific method was the essence of all human knowledge, cross-cutting the natural sciences and social sciences. Its fundamental feature was 'the spirit of enquiry and acceptance of the right to question and be questioned' (Statement on Scientific Temper, 1992:192-93). Viewing knowledge as open ended and evolving, the statement unequivocally noted that Scientific Temper was incompatible with theological and metaphysical beliefs. While science was

universal, religions and dogmas are divisive (Mahanti, 2013).

The Statement evoked strong responses, both positive and negative, in certain circles of academia (Chadha, 2005; Prasad, 1982; Popli 2003). A number of articles and letters were published in two magazines viz., *Mainstream* and *Secular Democracy*. Asish Nandy issued a counter-statement entitled 'A Counter Statement on Humanistic Temper' and he declared 'The ultimate logic of scientific temper is the vulgar contempt for the common man it exudes' (Nanda, 2003:207).

Scientific Temper Statement Revisited-2011: The Palampur Declaration

In 2011, an attempt was made to revisit the 1981 Statement of Scientific Temper. The document prepared and adopted during the national consultation is known as the 'Scientific Temper Statement Revisited-2011: The Palampur Declaration'. This was later revalidated in an international conference on scientific temper organised by the four premier agencies of the Government of India viz., Council of Scientific and Industrial Research-National Institute of Science Communication and Information Resources (CSIR-NISCAIR), National Council of Science Museums (NCSM), National Council for Science and Technology Communication (NCSTC) and Vigyan Prasar in January 2012 in New Delhi.

The Palampur Declaration begins by reiterating the notion of Scientific Temper, the Statement underlines the fact that science has made it possible to understand life, mind and universe without taking recourse to supernatural and revealed knowledge. Moreover, scientific knowledge is universal (Mahanti, 2013). The Palampur Declaration does not abandon practical and useful traditional knowledge simply because it is traditional. "The pace of technological intrusion, without essential back-up support of scientific knowledge base, introduces cultural and social distortions within traditional cognitive structures. Lack of effort in providing the necessary complementary scientific knowledge base to the population at large is consolidating these distortions resulting in the erosion of democratic structures. Moreover, technology-driven modernisation creates a cognitive gap due to loss of traditional knowledge, which is being filled in by reiligiosity in new forms" (Scientific Temper Statement: Palampur Declaration, 2011) (Mahanti, 2013).

'Science', 'Scientific Literacy' and 'Scientific Temper' in different Curricular Documents, Post-independence

1. Scientific Policy Resolution (SPR), 1958

The Indian Parliament adopted the Scientific Policy Resolution (SPR) of 1958, which enunciated the principles on which the growth of science and technology would be based. The SPR-1958 asserted that the Government of India visualised modern science and technology as the chief instrument for social transformation. The dominating feature of the contemporary world is the intense cultivation of science on a large scale, and its application to meet a country's requirements. For the first time in the human history known to us, the people living in countries advanced in Science got the opportunity of working on their standard of living and social and cultural amenities, which once was confined to a very small privileged minority of the population. It is only through the scientific approach and method and the use of scientific knowledge that reasonable material and cultural amenities and services

can be provided for every member of the community (SPR, 1958).

The document 'Science and Technology Policy 2003' of the Government of India urges the it its own way and intends to ensure that the message of science reaches every citizen of India, man or woman, young or old, so that we can advance scientific temper, and emerge as a progressive and enlightened society, and make it possible for all our people to participate fully in the development of science and technology and its application for the welfare of mankind. It further emphasises that only this way science and technology will be fully integrated with all spheres of national activity. (Science and Technology Policy, 2003)

In 1964, a Society for the Promotion of Scientific Temper (SPST) was launched. Its sole objective was to promote scientific temper in the society. However, the Society did not survive long. Bhargava and Chakrabarti wrote: 'The Society for the Promotion of Scientific Temper died a natural death: this chapter on development of scientific temper in the country was closed but many lessons were learnt from it, one of them being that scientific temper was an important ingredient of any recipe for not only social and economic but also scientific and technological advancement of our country'(Bhargava and Chakrabarti, 2010:26-29).

2. National Policy on Education 1968

The National Policy of 1968 marked a significant step in the history of education in post-independence India. It aimed to promote national progress, a sense of common citizenship and culture, and to strengthen national integration. It laid stress on the need for a radical reconstruction of the education system, to improve its quality at all stages, and gave much greater attention to science and technology, the cultivation of moral values and a closer relation between education and the life of the people (NPE, 1986: p.2). On the basis of the report and recommendations of the Education Commission (1964–1966), the then government announced the first National Policy on Education in 1968, which called for a "radical restructuring" and equalise educational opportunities in order to achieve national integration and greater cultural and economic development.

This policy has very strong views about 'Science Education and Research'; it states "With a view to accelerating the growth of the national economy, science education and research should receive high priority. Science and mathematics should be an integral part of general education till the end of the school stage." (NPE, 1968)

3. National Policy on Education, 1986

The National Policy on Education came in 1986, according to this policy among the essence and roles of education; one of the important points is that 'Education has an acculturating role. It refines sensitivities and perceptions that contribute to national cohesion, a scientific temper and independence of mind and spirit - thus furthering the goals of socialism, secularism and democracy enshrined in our Constitution.' (NPE, 1986: p.4)

It further states that the National System of Education will be based on a national curricular framework which contains a common core along with other components that are flexible. The common core will include the history of India's freedom movement, the constitutional obligations and other content essential to nurture national identity. These elements will cut across subject areas and will be designed to

promote values such as India's common cultural heritage, egalitarianism, democracy and secularism, equality of the sexes, protection of the environment, removal of social barriers, observance of the small family norm and inculcation of the scientific temper. In addition to all this educational programmes will be carried on in strict conformity with secular values (NPE, 1986: p.25).

Discussing about Science Education, the policy document stated its intentions that Science education will be strengthened so as to develop in the child well defined abilities and values such as the spirit of Inquiry, creativity, objectivity, the courage to question, and an aesthetic sensibility. Science education programmes will be designed to enable the learner to acquire problem solving and decision making skills and to discover the relationship of science with health, agriculture, industry and other aspects of daily life. All the efforts should be made for bringing-in those who have been deprived from science education, due to not being the part of formal education system (NPE, 1986: p.29).

4. NCF, 1975 (The Curriculum for the Ten Year School: A Framework, 1975)

The Curriculum for the Ten Year School: A Framework, brought out by NCERT in 1975, attempted to give concrete shape to the recommendations of the Education Commission and also to the Resolution on National Policy of Education-1968. It represents the first attempt to restructure and reorient the content and processes of school education based on a National Curriculum Framework (NCESE, 1988: p.2).

The subject of Science was quoted as the integral part of the curriculum up to Class X. The teaching of Science was recommended to be upgraded and the curriculum continually renewed which moved towards giving the children modern knowledge, develop their curiosity, teach them the scientific method of inquiry and prepare them for competent participation in a changing society and culture, increasingly dependent on a rational outlook leading to better utilization of Science and Technology (NCF, 1975: p.4).

Among the major objectives of education of Children one of them was to develop 'techniracy', which parallels to 'literacy', 'numeracy', etc. To do so the child should learn the method of inquiry in Science. This can strenthen their thought process and enable them to start appreciating Science and Technology in the life and world around them (NCF, 1975: p.11).

The curriculum also focuses on developing in the students the competence to apply their knowledge to the solution of the problems around them. They should have an understanding of the technological processes in agriculture and industry in use in their surroundings. They should be able to contribute meaningfully to environmental conservation, the reduction of pollution, the development of proper nutrition and health and hygiene in the community and their (NCF, 1975: p.13).

The above excerpts very well reflect that in the NCF, 1975, the subject of Science was treated very importantly, the direct usage of 'Scientific temper' or 'Scientific literacy' was not evident but the attributes which combine to constitute the same were emphasised a lot.

5. NCESE, 1988 (National Curriculum for Elementary and Secondary Education: A Framework, 1988)

The subject Science has got a very prominent place in this framework, the subject starts as a part of Environmental Studies at the primary

stage and is starts as a part of Science from the upper primary upto secondary stage. This document states that Science should be treated as one of the curricular areas that plays a decisive role in equipping the learner in understanding, interpreting and dealing with various things and phenomena around them in a more scientific way. Education in science should aim at developing well defined abilities in all the three domains which are cognitive, affective and psychomotor domains which are reflected in spirit of inquiry, creativity, objectivity, the courage to question and aesthetic sensibility. (NCESE, 1988: pp. 24-25)

This document very properly has a section on 'Inculcation of the Scientific Temper' in its very first chapter, which is believed to be the stating of the acceptance in its basic form the word 'Scientific temper'. The part is reproduced verbatim here in after:

The curriculum at the school stage should help the individual in developing scientific temper and rational outlook which are characterised by a not-taken-for-granted attitude. The role of education in refining sensitivities and perceptions that contribute to scientific temper and independence of mind has been well recognised. The curriculum should develop in the pupil well defined abilities and values such as the spirit of inquiry, objectivity and the courage to question. There is a need to design various educational programmes in such a way that they would enable the learner to acquire problem solving and decision making skills. The emphasis of curriculum at different stages of school education, therefore, should be on developing in every pupil of qualities such as open mindedness, commitment to free inquiry, a habit of seeking more evidence before arriving at conclusions and a readiness to revise assumptions and hypotheses based on fresh evidence coming to light, all directed to the inculcation of the scientific temper. In teaching of various subjects it is important to keep in mind the interdisciplinary nature of the current scientific researches happening in the present scenario. Interdisciplinary and less segregation in teaching of various subjects seem to emerge as significant both in the context of our efforts to provide a broad-based education at the school stage and to prevent overcrowding of the school curriculum (NCESE, 1988: p.9).

6. NCFSE, 2000 (National Curriculum Framework for School Education, 2000)

The curriculum framework of 1988 gave much emphasis on improving science education in schools, but that was not sufficient. There were many more reforms needed to strengthen the system. The National Curriculum Framework for School Education, 2000 was more focussed towards inculcating, intrinsic values, cultural heritage, ethos, international brotherhood and emotional intelligence, etc. Still it stresses on developing 'scientific temper'. The document for example states that the school curriculum has to help generate and promote among learners scientific temper which includes spirit of enquiry, problem-solving, courage to question and objectivity. This will lead to elimination of obscurantism, superstition and fatalism, and at the same time it will sustain and emphasise the indigenous knowledge ingrained in the Indian tradition (NCFSE, 2000: p. 40). This is marked that in this curriculum framework teaching the subject of Science was given very much importance at all levels of school education.

7. NCF, 2005 (National Curriculum Framework, 2005)

Among the NCFs the NCF 2005 being

the recent, is currently as the means of providing guiding principles for developing any curriculum throughout the country. NCF 2005 states that a curriculum should connect knowledge to life outside school. It should ensure that learning is shifted away from rote methods. There should be the enrichment of the curriculum to provide a base for the overall development of children rather than making them textbook-centric. The NCF also aims to make examinations more flexible and integrated into classroom life. The broader aim of the NCF includes the nurturing of overriding identity informed by caring concerns within the democratic policy of the country.

According to NCF (2005) the teaching of Science should be recast so that it enables children to examine and analyse everyday experiences. Through various activities, involving outdoor projects concerns and issues pertaining to environment must be addressed across subject areas. Some of the information and understanding flowing from such projects could contribute to the elaboration of a publicly accessible, transparent data base of India's environment, which would in turn become a most valuable educational resource. This will develop in students critical thinking and problem solving abilities. Moreover, if well planned, many of these student projects could lead to knowledge generation.

While talking about Scientific literacy we cannot forego 'Scientific Temper'. Spread of Scientific Temper in society is much more improtant than the spread of Science or technology. It is an attitude of mind which calls for a particular outlook and pattern of behaviour. It is of universal applicability and has to permeate through our society as the dominant value system powerfully influencing the way we think and approach our problems which can be political, social, economic, cultural and educational.

Scientific Temper involves the acceptance, amongst others, of the following premises:

a. The method of Science provides a viable method of acquiring knowledge.

b. Human problems can be understood and solved in terms of knowledge gained through the application of the method of Science.

c. The fullest use of the method of Science in everyday life and in every aspect of human endeavour from ethics to politics and economics- is essential for ensuring human survival and progress.

d. People should accept knowledge gained through the application of the method of Science as the closest approximation to truth at that time, and question what is incompatible with such knowledge; and that one should from time to time re-examine the basic foundations of contemporary knowledge.

The National Curriculum Framework 2005 is designed to transform India's Educational System and incorporate a child centered system that promotes joyful learning among students. It emphasises that curricula, syllabi and textbook should enable teachers in organising the classroom experience as per the needs of all students and the learning environment. Such child centric education is meant to help in reducing students stress.

The NCF 2005 states at many places that Science is a dynamic and evolving discipline, and it is propeled by human curiosity and desire to see patterns in meaningful relations. Science should nurture curiosity and creativity, particularly in relationship to the environment. Science content transacted by the teacher should be understandable to the students, be placed in the context of children's environment to help them understand the practical application of concepts

and not just theoretical understanding, it should enable children to examine and analyse everyday experiences, create awareness on environmental concerns. Science teaching should convey significant aspects of scientific content at appropriate level; engage the child in learning the process of acquiring and validating scientific knowledge. All this shows that Science teaching and learning has got special mention in the NCF 2005 document, but on the same time the term 'scientific literacy' is not directly mentioned in the document. In the position paper of the National Focus Group on 'teaching of Science' this term is discussed only at one place. This situation is disturbing and needs a concentrated effort for providing more emphasis on it. The NCF 2005 document suggests the steps like, using teaching methods such as experimentation, group activities, field trips, excursions, etc.; attempting discussions with co-teachers and students, participating in surveys, organization of data; and display of students' work in schools and in community as a help in the development of scientific literacy in the students.

According to the Position Paper of National Focus Group on 'Teaching of Science' (p.11) one of the aims of Science Education is to cultivate 'scientific temper'- objectivity, critical thinking and freedom from fear and prejudice. In the same document at another instance (p. 28) it is stated that Science learning should be used as an instrument of social change to reduce the socio-economic divide. It should help to fight feelings and issues like prejudice, gender, caste, religion and region. Science education ought to empower students to question the social beliefs, notions and practices that keep social integrity alive (NFG on Teaching of Science, NCF, 2005).

8. NCFTE, 2009 (National Curriculum Framework for Teacher Education: Toward Preparing Professional and Humane Teacher, 2009)

Focussing on carving the teacher's personality, in being humane to the learners, the NCFTE, 2009 was developed. It has a bearing on transforming the very dynamics of teacher education per se. Two significant developments particularly, the National Curriculum Framework 2005 and the Right of Children to Free and Compulsory Education Act 2009 as well as the fundamental tenets enshrined in the Constitution of India have guided the development of this Framework. This document has given due importance to the teaching and learning process of Science, at many places it talks about the teacher training of Science teachers for making them well equipped with perfect pedagogical practices of teaching Science.

Concluding Remarks

Development of scientific literacy and scientific temper constitute the backbone of an ideal Science curriculum. The journey of Science as a part of curriculum and its necessary attributes assimilated in the veins of the generations is quite a journey. The present National Curriculum Framework 2005 is designed to transform India's Educational System and incorporate a child centered system that promotes joyful learning among students. Science is a dynamic and evolving discipline, and it propels human curiosity and desire to see patterns in meaningful relations. Science should nurture curiosity and creativity, particularly in relationship to the environment. In today's context when India is on the verge of getting its New Educational Policy which will follow the development of the new National Curriculum Framework, it is

very important to review the existing version in order to ascertain that all the gaps are filled while developing its new version especially in terms of development of scientific temper and scientific literacy.

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