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CONFLICTS OF SCIENCE TEACHING: AN ANALYSIS OF NCF VISION AND GROUND REALITIES

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Abstract

The National Curriculum Framework, 2005 envisions the development of scientific temper through science education at each stage in class-rooms in India. But due to various reasons discussed in the paper, more often than not, science education fails to develop the scientific temper in its students. To analyse the causes, a case study of the science education in the government schools of Haryana was done and some interesting points emerged for future discourse including (a) Lack of basic amenities for science teaching in government schools (b) inefficacy of pre-service and in-service teacher training programs, (c) Curriculum is too huge to be covered through organising practical teaching-learning experiences, (d) government teachers are reluctant to take pains due to job-security. This paper hopes to open a discussion on the ways and means to make science education a "systematic experimentation as a tool to discover/verify theoretical principles, and working on locally significant projects involving science and technology" that has been envisioned to be an important part of science curriculum at senior secondary level by National Curriculum Framework, 2005.

Keywords: *Teaching of Science, Issues in Science-Teaching, Science Teaching for Development of Scientific Temper, Science Teaching in Government Schools in India.*

Introduction : The National Curriculum Framework, 2005 envisions the development of scientific temper through science education at each stage in class-rooms in India. The educational structure at post-elementary stages of education, viz. Secondary Education and Higher Education has been divided into three broad streams namely, Arts, Commerce and Science. The pedagogy of each and every stream is unique due to the huge difference in their nature. Each stream has to be dealt with its uniqueness with the methods and procedures suitable for it. But it is seen that in our classrooms, especially in government schools, Science education along with commerce education is imparted in the same manner as Art education is imparted. The focus remains on rote learning rather than Practical/experimental or survey methods that are suitable for Science and Commerce teaching respectively. (Private

schools are not in the ambit of this study, therefore, same observation cannot be held true about them in spite of the possibility of the scenario being more or less same there also.)

Instead of rote learning, pedagogy of science requires that the child should be engaged in joyfully exploring the world around and harmonising with it. The objectives should be to nurture the curiosity of the child about the world, natural environment, its artefacts and people. The child needs to be engaged in exploratory and hands-on activities for acquiring the basic cognitive and psychomotor skills through observation, classification, inference, etc. The child should be engaged in learning the principles of science through familiar experiences, working with hands to design simple technological units 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. 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. Generally speaking, content, process and language of science teaching must be commensurate with the learner's age-range and cognitive reach. Science teaching should engage the learners in acquiring methods and processes that will nurture their curiosity and creativity, particularly in relation to the environment. Science teaching should be placed in the wider context of children's environment to equip them with the requisite knowledge and skills to enter the world of work. Awareness of environmental concerns must permeate the entire school curriculum.

For various reasons, all these approaches and practices are either not adopted at all or not adopted to the required level in most of the government schools of India. Science students are just made to learn the facts and figures given in science text-books to regurgitate in the examination hall. The result is that, more often than not, science education fails to develop the scientific temper in its students. First of all it is important to build up an understanding of what is meant by the term "Scientific temper". "*Scientific temper describes an attitude which involves the application of logic*".(Wikipedia) The scientific temper/attitude is characterized by following traits:

a. **Healthy scepticism**: An attitude of not accepting others' assertions or directions unless these are logical, rational and substantiated by evidence. It is an antidote to the credulous taken-for-granted attitude of accepting things merely on the basis of authority or tradition. Scepticism means that one doesn't even have to necessarily 'believe' in the evidence provided. One can re-perform the experiments and determine whether the evidence is

trustworthy or not. Scientific temper precludes acceptance of evidence that is not reproducible by others, and is claimed to be the exclusive prerogative of a select few.

b. **Universalism**: Universalism is an important characteristic of scientific temper. There is no place for prejudice or bias; otherwise the conclusions can not be universal.

c. **Freedom from prejudice or bias**: The observations have to be objective. You observe things as they are, without trying to manipulate these to fit in some pre-conceived worldview. This also demands an open mindedness, willingness to change conclusions in the light of reliable evidence and humility, freedom from pride and arrogance, which comes from realization of limitations of our intellect and ever broadening horizons of knowledge.

d. **Objectivity**: It means the absence of prejudice/ bias or influence of personal opinions, likes and dislikes. "**Objectivity** in science is a value that informs how science is practiced and how scientific truths are discovered. It is the idea that scientists, in attempting to uncover truths about the natural world, must aspire to eliminate personal biases, a priori commitments, emotional involvement, etc. Objectivity is often attributed to the property of scientific measurement, as the accuracy of a measurement can be tested independent from the individual scientist who first reports it. It is thus intimately related to the aim of testability and reproducibility." (Wikipedia)

e. **Open mindedness and humility:** Open-mindedness is an attitude in which an individual does not reject any knowledge that conflict with his or her own views. It involves admitting that "I" am not free from committing errors. One recognizes that there may be better ideas and realizes that there are individuals whom he may have to consult to arrive at correct observations and conclusions.

f. **Willingness to suspend judgements which are not supported by sufficient evidence:** A person with scientific temper gives a truthful report of observations. He does not withhold important information just to please himself or others and is always willing to suspend judgements which are not supported by sufficient evidence,

g. **Rationality:** The hallmark of decision-making by a person with "scientific temper" is logic and rationality. Rationality is an attitude of an individual that believes that things happen with a cause. He or she does not believe in the superstitious belief rather' he or she accepts facts but only with supported as well as convincing proofs.

h. **Perseverance** – It involves positive approach to failure and usually follows hard toil and reflection on the problem for long periods of time.

Why should one strive to develop "scientific temper"?

First of all, as a citizen of India, it is the constitutional duty of every citizen to develop scientific temper as mandated in the Art. 51A, part IVA of the Indian Constitution, which specifies the list of fundamental duties of the citizens. It says "it shall be the duty of every citizen of India: "to develop the scientific temper, humanism and the spirit of inquiry and reform." It is the duty of every true citizen of India to acquire those attributes and to wage war on the enemies of the scientific temper.

Besides it being a constitutional duty, it is also the extremely important for the development of our country as India has not won even a single Noble prize in science and most of the technology is imported. No major technological breakthrough has been done by India. And if leave aside the major scientific discoveries, even the everyday life of people of India is still reeling under blind belief and superstition, belief in the power of destiny rather than intelligent efforts. A person with scientific temper cannot go hand in hand with metaphysics, theology/religion, especially when it incorporates miracles. Almost all religions are based upon alleged revelations, beliefs in supernatural beings and in after-life and have fossilized rules of conduct called morality that have no connection with the secular, present day needs of mankind. Belief in supernatural beings capable of affecting human destiny is wholly dangerous to a rational living. It may lead to a lack of interest in present life and to a concern for an imaginary salvation in the other world. It tends to inculcate a feeling of guilt in the mankind for sins imagined or otherwise and prevents him from realising his potentiality as a human being. To free coming generations from unverified beliefs superstitions, guilt and silly pursuits, it is the prime duty of the science teacher to inculcate scientific attitude in the students while imparting science education.

Therefore, in a country like ours, where a large section of the society is still caught in the quagmire of superstitions and obscurantist practices, inculcating scientific temper among the citizens is of paramount importance for development of the nation. This is best done during the childhood while the child is learning how to respond to the vagaries of everyday life. It is therefore essential that the school curriculum should respond adequately to this important need. This demands inculcation of values like spirit of inquiry, courage (to question), objectivity, honesty and truthfulness, which are precursors to the development of various traits characterizing scientific temper. The spirit of inquiry, so natural in most children actually gets stifled by the drab teaching-learning environment created by the didactic teaching methodology. Even learning of science, which should be a joy of discovery, becomes a burden–memorizing so many 'facts', formulae, chemical reactions, etc. It is

therefore of paramount importance that education process be made joyful, with the teachers acting as facilitators of learning, as friends and guides. The child must be free to learn, what he chooses to, at the pace that he relishes, and must be free to make mistakes without the fear of being reprimanded by the teacher. There exist numerous success stories of schools where education is imparted by a variety of means like stories, painting, recitation, games, group projects, self-reading etc. so that the child's enthusiasm for learning does not diminish. In such schools the children are not afraid of asking questions from their teacher friends, and thus their inquisitiveness is strengthened. An effective method of fostering scientific temper is imparting knowledge of science through experimentation and demonstration, by involving students directly in activities similar to how scientists operate in discovering new knowledge. This is usually referred to as the discovery approach to teaching and is eminently suited to teaching science. Clearly teaching of science in this manner would greatly develop scientific temper among the students for, as goes the Chinese proverb:

"I hear, and I forget;
I see, and I remember;
I do, and I understand."

To inculcate scientific temper among the students they need to be placed in situations – through role play, quizzes, model making etc. - where critical and rational thinking are needed. We also need to make them aware of the impact of science on society by arranging visits to factories, hospitals, research laboratories, showing suitable video films, organizing talks by eminent scientists and technologists, and encouraging them to participate in science exhibitions. The attributes of scientific temper like, honesty, truthfulness, humility, perseverance, positive approach to failure, are essentially some of universal human values which are quite important for happiness of an individual as also the society. Inculcation of these and other universal human values should become an integral part of the education process.

An analysis of Conflicts of Science teaching *vis a vis* NCF Vision and Ground Realities: A Case Study

The National Curriculum Framework, 2005 envisions the development of scientific temper through science education at each stage in our class-rooms. To analyse the conflicts of science teaching *vis a vis* NCF Vision and Ground Realities, a case study was done by the author of this paper. 70 randomly selected science teachers working in government schools of Haryana, selecting 10 from each of seven Educational Development/ Community Development Blocks (ED/CD Blocks) were interviewed through semi-structured interviews.

Some interesting points emerged from this case study conducted by analyzing and interpreting the data collected through semi-structured interviews. Following is the analysis of the conflicts between the NCF Vision and the Ground Realities.

NCF Statement 1: "The teaching of science should be recast so that it enables children to examine and analyse everyday experiences."

Conflicting Ground Reality: The teachers teaching at secondary level complain that the students need to be prepared at primary and elementary levels. Since there are no such facilities in terms of infrastructure and training in pedagogy of science either at elementary or secondary level to develop the understanding of how different science is from other subjects (Arts or Commerce), teacher at all levels teach it just like humanities subjects which the students are required to memorize and regurgitate at the time of exams in the absence of real understanding of the concepts and skills to apply these in real life. In such a scenario, where is possibility of development of scientific temper?

NCF Statement 2: "Our educational practice is still based on limited 'lesson plans' aimed at achieving measurable 'behaviours'; according to this view, the child is akin to a creature that can be trained, or a computer that can be programmed. Hence, there is too much focus on 'outcomes', and presenting knowledge divided into bits of information to be memorised directly from the text or through activities after 'motivating' children, and finally on evaluating to see if children remember what they have learnt. Instead, we need to view the child as 'constructing knowledge' all the time. This is true not only of 'cognitive subjects' such as mathematics and science, language and social science, but equally of values, skills and attitudes."

Conflicting Ground Reality: They complain that the policy of department is so rigid that they are compelled to complete the syllabus "within prescribed time" and do not "waste time" on anything else. They further explain that the Education Department (In Haryana) has prescribed each and every topic which is to be finished in a month and a monthly achievement test (MAT) is conducted every month to evaluate how much the students learnt from the subject matter taught this month. This doesn't let the teacher do much innovations in the form of self designed activities or experiments which the teachers deems necessary to inculcate scientific temperament in the students.

NCF Statement 3: "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."

Conflicting Ground Reality: Teachers are not aware of the meaning and process of scientific query; they barely assume that what maximum they can do apart from taking theory classes is doing few experiments in the lab. They do not have any idea what else is required on the part of teacher to be done with students to help them developing a scientific attitude/temperament. Therefore they complain for lack of refresher courses or capacity building workshops.

NCF Statement 4: "Textbooks themselves should be seen as opening up avenues for further enquiry, and students should be encouraged to go beyond the textbook to further reading and observation."

Conflicting Ground Reality: They think that doing anything extra shall spoil the student's time and they will not be able to complete the syllabus within the prescribed time limit between two consecutive MATs. Moreover, there are no reference books or study material available in government schools which can be provided to the students to read beside the prescribed text books.

NCF Statement 5: "Laboratories have always been talked about as a part of science teaching in middle and high school. Yet these are still not available on the scale required. As a part of the effort to provide all children with the necessary hands - on experience of equipment and experiments given in their science curriculum, at least at the cluster level, the resource centre may serve as a cluster lab. Schools in the cluster could plan their timetable so that for half a day, once a week, their science lab class is held at the cluster - level lab. Craft labs too could be developed at least at the cluster or block levels in order to facilitate access to better equipment. In engendering a culture of learning, not only the classroom but also in the space

of the school itself and the world outside, the school could become the landscape in which a range of activities are organised. Teachers can devise activities, projects and studies, both drawing from textbooks and going beyond them, to encourage children to explore, investigate and construct knowledge**".**

Conflicting Ground Reality: Lethargy on the part of teachers: Teachers, although unofficially, admit that we, ourselves, avoid going to the labs or performing any activity that can enrich the rational and independent thinking in our students. The lack of motivation and training along with time constraints to accomplish prescribed syllabus may be the reason for such lethargy on the part of teachers. Bulky syllabus, expired/outdated or out of stock chemicals and lab manuals are the reasons that add to the existing problems such as laboratories are shaggy and overcrowded with almost no facilities like water, gas supply, lab attendants etc. In addition to this, teachers find themselves almost blank regarding "How to prepare the students (and even themselves) to perform experiments. Most of the time, they are confident that students need not perform any practical because the teachers are quite good at explaining the topic 'theoretically'. They perceive that the students unable to draw any inferences from the experiments done in the laboratory. Though the students enjoy working in the laboratory but they are almost unable to connect that lab work with the theory. This can be treated as inability of the teachers instead of students if analysed properly.

NCF Statement 6: "Indeed, all great inventors were tinkerers who knew a little science. Edison, Ford and Faraday belonged to this category, so also those who invented the first pair of spectacles or the telescope. There is little doubt that much of the traditional knowledge of our potters, craftsmen, weavers, farmers and medical men has come through such pursuits – where these individuals were simultaneously engaged in physical work and academic thinking. We need to infuse such a culture of innovation, curiosity and practical experience in our education system."

Conflicting Ground Reality: Teacher complain that the policy of department is so rigid that they are compelled to complete the syllabus "within prescribed time" and do not "waste time" on anything else. And therefore, teachers opine that **a**ny extra activity to inculcate the habit of thinking rationally or to raise questions, is not at all required. Even the 'best science' teachers do not do anything besides making the students finish the syllabus on time and making students memorize it several times so that they do not forget any fact, figure or formula in the exams. They do not know the ways and means making the student's attitude as "scientific". And to add to this, there is little provision for any effective capacity building program for science teachers be it pre-service or in-service.

This is clear that the problem does not lie at the level of teachers merely rather this lies along the whole enterprise of education. Actually science labs are merely used to showcase the tools and are opened at the time of inspections only. If infrastructure is created and used too, even then teachers are unable to do something to inculcate scientific temperament by doing some experiments in the laboratories to trigger their minds to think beyond the facts and figures served to them since years.

NCF Statement 7: "Teacher autonomy is essential for ensuring a learning environment that addresses children's diverse needs. As much as the learner requires space, freedom, flexibility, and respect, the teacher also requires the same. Currently, the system of administrative hierarchies and control, examinations, and centralised planning for curriculum reform, all constrain the autonomy of the headmaster and teacher. Even when there is curricular freedom, teachers do not feel confident that they can exercise it without being taken to task by the administration for doing things differently. It is therefore essential to enable and support them in exercising choice. As much as the classroom needs to nurture a democratic, flexible and accepting culture, so also the school institution and the bureaucratic structure need to do the same. Not only should the teacher receive orders and information, but equally the voice of the teacher should be heard by those higher up, who often take decisions that affect the immediate classroom life and culture in the school. Relationships between teachers and their heads and principals must be informed by equality and mutual respect, and decision making must be on the basis of dialogue and discussion. The annual, monthly and weekly calendars of activities need to provide time for such staff interactions for reviewing and planning. There is a need to encourage an atmosphere that facilitates collaborative efforts among teachers. There must also be mechanisms for conflict resolution. Often technologies such as radio and TV are introduced into their classrooms without consulting teachers on whether they would like to have these and what they would like these to do for them. Once these there in the classroom, teachers are expected to use them, when they have no control over what will be delivered, or how it will integrate with their own teaching plans".

Conflicting Ground Reality: There is no autonomy on the part of teachers or even at school level. It is already mentioned that they complain for rigid timeline to finish prescribed portions of syllabus within stipulated time meaning thereby, the teachers, if they even wish to do something, they can't.

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.

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 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.

Conclusion:

As said in NCF, 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."

But it can be easily concluded from the present discussion that including 'rich words & phrases' in the policy documents or the National Frameworks does not serve the purpose. The implementation part needs be enriched and enhanced sufficiently. The teacher is the key person at execution end and therefore the policy makers as well as implementers need to sit together and devise (as well as design such need based trainings and capacity building programs which suit the needs and nature of teachers. Further, the issues raised by the teachers cannot be (and should never be) rejected merely treating them as 'an excuse' for 'non-commission' or 'omission' on the part of teachers. In addition, teachers need be given fair autonomy (if not full) to try innovations and design such activities (as per their local needs, stuff of students) as they find suitable. Teachers training programs, especially in D.Ed, B.Ed etc must be so designed that the future teachers do not feel incapable or frustrated when they go to the real field of teaching. Until and unless they develop the ability to deal each stream with its uniqueness of methods and procedures suitable for it, they should not be sent to the classrooms. So long as no such concrete step are taken besides writing bulky policy documents with lucrative words and phrases, development of scientific temper through science education will remain a distant dream.

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