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ARTICLE

Science Education in India: A Misnomer for Scientific Temper

NAVNEET SHARMA[1], YUSUF AKHTER[2] & SHOWKAT AHMAD MIR[1]

[1]Department of Teacher Education, School of Education,
Central University of Himachal Pradesh, Dharamshala.

[2]Department of Biotechnology, School of Life Sciences,
Babasaheb Bhimrao Ambedkar University, Lucknow.

E-mail: navneetsharma29@gmail.com; yusuf@daad-alumni.de;
showkatmir09@gmail.com

ABSTRACT

Indians being 'argumentative' can even justify the indefensible and the conventional scientific logic and rationality appear amorphous and adjustable to us, which can be tailored to justify our firmly held superstitious beliefs and obscurantist practices. Scientific temper is a requisite to evolve an 'Ask why' society to sustain and reinvigorate the Indian democracy, which needs to be re-understood in the context of popular culture and pedagogical practices of science education. In this article, we tend to problematize what is scientific temper? Why scientific temper continues to elude us despite being part of our constitutional fundamental duty and framework. The aim is to negotiate with the idea of science as understood by Indians, while simultaneously deconstructing the idea of Indian science. The article will also explore the pedagogical concerns of science education in India. The penultimate question would be about the possibility of evolving scientific temper with the contemporary science education policies and system. The paper attempts to analyze how science education in Indian classroom settings continues to evade evolvement of scientific temper.

KEYWORDS: Science, Science education, Scientific temperament, Indian classroom, Values

Introduction

"If we have to regain our place in the world and are not to be relegated once again to the dustbin of history; if we wish to offer a life of fulfillment to our destitute millions; indeed, if the light of our civilization is not to be extinguished, we have to

undertake, on a priority basis, the task of nurturing scientific temper." (Haksar et al., 1981)

What is Scientific Temper? Jawaharlal Nehru explained the term scientific temper in his most celebrated book *The Discovery of India*. For Nehru, this could be how an individual behaves in his day-to-day life. It may be defined "as his way of thinking, and acting upon his thoughts in any social settings, it must use the scientific methods, and which may therefore, include posing questions, observing physical reality, critically testing its existence, hypothesizing, analyzing, and communicating the inferences not necessarily in the order described"(Nehru, 1946). Ultimately, scientific temper describes an attitude, "which involves the application of logic, discussion, argument and analysis are vital parts of this approach. Elements of fairness, equity and democracy are automatically built into its framework" (Balasubramanian, 2005).

Scientific temper should not be mistaken with inculcating technological and scientific expertise or infrastructure building in science and technology; rather the development of scientific temper in masses of the country is a philosophical and pedagogical objective. For instance, India after independence has made a great success in the field of science and technology which is evident from its success and milestones achieved, from acquiring the atomic power to the low budget, but highly successful Indian Space Research Organisation's Mangalyan mission or the huge IT revolution contributed by India. Scientific temper pertains to a way of thinking or a viewpoint rather than a specialized body of knowledge. Unlike scientific expertise alone, the project of scientific temper is a call for the diffusion of scientific inquiry into the thoughts across the huge population of this country. The growth of scientific temper should be measured by the extent to which ordinary people use the methods of science to their own lives' issues (Roy, 2007). Therefore, the 42nd amendment to the Indian Constitution in 1976, enshrined in the list of Fundamental Duties vide Part IV-A, Article 51-A (h) called on every Indian citizen: 'to develop the scientific temper, humanism and the spirit of inquiry and reform.'

The question is often asked why in the Indian society in general superstitious and blind faith still persist despite

systematic challenges from the likes of Dabholkar and Kalburgi. The respectable literacy rate of almost seventy percent and cent percent school enrollment of children since more than a decade due to the right to education, why are we still governed by religious, casteist and gendered overtones. The rising graph of religious and caste divides and plummeting sex ratio and social harmony makes us wonder why we and our schools have failed to inculcate scientific temper among the larger population.

Science and science education have been overly emphasized in our concerns for education and national development since 1947. Is it the curricula of science education or the conventional pedagogy of science teachers or the overall emphasis on rote learning for performance in examination that are to be held responsible for the lack of evolvement of scientific temper.

Only that age should be called a scientific age in which the problems of the society are faced and handled by people with scientific temper. Only that society can be called a "scientific" society which is composed of men and women who display scientific attitude in their daily lives. Only those classrooms should be called scientific classrooms where scientific methods are used to engage students. So, scientific temper, a rational attitude has to be fostered with care at the individual, social and political levels. Because, "...a scientific mind is an adventurous mind, it is not afraid of the truth because it may clash with established systems of thoughts, beliefs, and superstitions—some of them claiming to be the products of mystic experience or metaphysical speculations" (Jahagirdar, 2011).

A scientific mind, scientific temper, scientific attitude — these are not the monopoly of scientists alone. Indeed not all practicing scientists display a scientific approach in their daily lives and many examples could be given of this. Despite being educated in science, scientific temper as a response fulcrum often does not become operative and functional. Being trained in science it is expected that scientists would abide by the scientific method to test the hypothesis before arriving at a conclusion.

The scientific method requires the formulation of a hypothesis on the basis of known knowledge and collection of

additional data or newer facts to test the validity of the hypothesis. The validity of the hypothesis is not tested merely by the gathered facts or data. The deductions of a hypothesis are worked out and tested. There is no self-evident truth in science or knowledge constructed via the scientific method. Hypothesis is only a stage in the inquiry, and therefore, it must lead to the answer to the problem, which has initiated the inquiry. A hypothesis may also be tested by an experiment in a given case. In the process, a hypothesis may be modified or is rejected in favor of another justified hypothesis.

In other words, a scientist or an individual with a scientific temper or attitude does not adhere to a proposition or conjecture merely because it is more convenient or because it is more suitable to his individual perception. One cannot impose one's own hopes or desires on the course of the quest of knowledge. As Faraday urged, "The world little knows how any of the thoughts and theories which have passed through the mind of the scientific investigator have been crushed in silence and secrecy by his own severe criticism and adverse examination; that in the most successful instances not a tenth of the suggestions, the hopes, the wishes, the preliminary conclusions have been realized" (Pearson, 1911).

It is only after a hypothesis is tested for its validity repeatedly that it is accepted as theory. However, even then it is not permanent and is only a conjecture waiting to be refuted or to be displaced by a new hypothesis and better explanatory theory. With the accumulation and growth of knowledge or with the need to explain some more or new phenomenon, the theory may be found wanting, it will require correction, modification and sometimes a decent burial. Though one of the conditions of a good hypothesis is that it must accord with the existing paradigm of knowledge, but it may happen and has happened that a hypothesis when tested may overthrow the present thesis and a new thesis or paradigm becomes the episteme. The Copernican Revolution is a classic example of this type of development. In other words, a scientist, according to Popper is not afraid of falsification of theory or his justified beliefs (Popper, 2009).

Scientific Temper and the Indian Society

The question why an individual or a society must abide by scientific temper takes us to another psychologically epistemic question: whether human beings are 'scientific' by nature or they are made aka to 'Beauvoir' [One is not born, but rather becomes women (Parshley, 1972)]? Or they are made or must be, to justify human evolution and existence! Another question, which is equally intriguing, is whether scientific knowledge is exterior to human beings or is it 'innate'? The question is whether human beings are 'naturally' non/unscientific and it is the milieu and the societal norms that make one scientific or is it vice versa – that human beings are born scientific and the society makes them non-scientific to unquestioningly accept the prevailing hegemonic knowledge.

George Kelly, an American psychologist believed that people are like naïve scientists who see the world through a particular lens, based on their uniquely organized systems of construction but equally potent arguments are put forth by A. Sullivan Palincsar in which she supports that there is interdependence of social and individual processes in the co-construction of knowledge in which schemata and heuristics of meaning making is provided by the social impetus. So, how and why the social milieu becomes scientific or unscientific (Kelley, 1955; Palincsar, 1998)?

Is the Indian social milieu scientific or non-scientific in nature? The authors are aware of the multiplicity of Indian contexts whereby they can observe absence or sparks of scientific temper in abundance. The Science/Scientific knowledge is confined to the idea of school and schooling and the larger gamut of education, which is non-formal or informal in the Indian context, remains unscientific. But, before the Indian context poses post-modern questions to the ideation of scientific temper, it should evolve through the phase of modern scientific rationalist society. It cannot take the illogical leap from pre-science/pre-modern scientific attitude to post-modern scientific attitude. The modern and modernity as sociological contexts and constructs are guided and shaped by the understanding of modern science. Before eulogizing the alternative, we must have 'access' to scientific reasoning/knowledge. Whether indigenous

knowledge is/was scientific or not, must be preceded with the access and appreciation of progressive scientific learning and pedagogy. It is akin to understanding and implementing the idea of de-schooling society, but first, we must 'school' the society. The question why 'scientific' rationality should be considered as the only rationality must be asked only in the light of philosophical rationality and not in the frame of jingoistic cultural and ethno-historical narratives. The notion of science and scientific knowledge must be assessed on the altar of philosophical skepticism but before that, we must realize that philosophical skepticism is different from the common-sense skepticism and the un-willingness to learn and inculcate scientific temper.

Being curious is a fundamental human nature, which inculcates and evolves into inventiveness and creativity during the lifespan of any individual if he/she is born and brought up in an environment that promotes scientific temper. In children, it is there as one of many genetic and inborn traits. It may transform into irrationality and orthodoxy due to nonscientific upbringing and mis-constructed curricula lacking scientific temper at primary and secondary levels of education. In this scenario, Lamarckism takes over Darwinism. The constant feeding of incorrect educational training at home and in school attenuates the natural scientific temper/instinct of the children.

The first training of the children starts from primary and secondary school education. Some of these children will become scientists of the future, who have passed through an educational pipeline that imbibed wrongly designed curricula based on beliefs and traditions rather than scientific temper. In the west, education/schooling given to children is based on principles of constructivism rather than on the mere transfer of facts from teachers to students. For instance in Germany, there is the option of Kindergarten (nursery school), which is provided for all children between one and six years old, where children get to learn the essentials of formal education, based on their observations and in vivo evolution of ideas. They are taught/engaged in a natural environment without any stationery but are sent to the gardens and playgrounds, so that they get to

feel the soil, grass, trees, etc. Kindergarten teachers let them 'observe' the natural entities like butterflies, soil, rain, water bodies and the snow and quiz them with questions which imbues and retains the quality of inquisitiveness within them, as advocated by Rabindranath Tagore and Mahatma Gandhi, which it seems has been lost somewhere in our 'progressive' education system.

Observation-based learning is a rational scrutiny, posing hypothetical inquiry, problem-solving and discovery driven multipronged process where students learn directly from their environment induced by their curiosity for the objects with which they interact in the surroundings. In return, they could also recognize and be able to learn the most necessary life skills demanded by the real world. This type of learning initiates thinking and reflection skills in them, and the inquisitiveness also catalyzes a production of intrinsic motivation and interest to learn new things in life.

We need to look at the education and schooling process beginning from curriculum development to evaluation and see how scientific insights and temper can be instilled amongst people to help them resolve their conflicts and livelihood issues. The advent of the 21st century and a globalized world has necessitated the agenda of reforming the curricula. The aim of science curricula reforms across the world has been to train students to develop critical and creative thinking through various innovative methods namely, learning by doing, learning by inquiry and promoting ambition to discover something new (Kumar and Singh, 2017). However, contrastingly, the structure of curricula in our school education only includes a teacher giving instructions which students will have to follow and cram and spit out during the examination. Constructive learning requires deeper inquiry than just remembering the facts.

Lack of trained science teachers and science communicators in schools is another major problem. Trained science communicators could play a role in the development of scientific temper in the society and their unavailability is a hindrance in developing an informed 'Ask why' society.

Developing Scientific Temper in Classrooms

The history of human civilization reflects that it is the scientific attitude and temper which created and promoted science and also gave humanity the means to affect the natural, social and political environment. It is, therefore, the scientific temper which is the most precious heritage of humanity. It is the result of incessant human labor, search and struggle for new knowledge and an egalitarian worldview and society.

To have or not to have the scientific temper, this question must be approached with that temperament only. What is it that an individual or society will gain when it imbibes scientific trait and temper in its perception and approach to make sense of the world. It is only with this temper that science as a discipline evolved in the late 18th century. Scientific temper precedes science and is the essence of this discipline. All knowledge that is gained needs to be treated as what Popper calls 'conjecture' and it should have inherent 'refutability', that is, the refutation of the arrived knowledge must be possible (Popper, 2009). Scientific knowledge grows, as Kuhn envisages, through paradigm shifts and these shifts occur when earlier constructed theories could not answer or hold the underlying assumptions/ newer questions (Kuhn, 2012).

"Scientific temper involves the acceptance, amongst others on the following premises, That the method of science provides a viable method of acquiring knowledge;…That the fullest use of the method of science in everyday life and in every aspect of human endeavor from ethics to politics and economics is essential for ensuring human survival and progress; That one should accept knowledge gained through the application of the method of science as the closest approximation of 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." (Haksar *et al.,* 1981)

The question of whether school or the pedagogy can inculcate scientific temper amongst learners can be explored at three different levels: first, how science is understood and taught at the elementary level; second, how learners are expected to engage with science at a later level of learning or in higher education; and third, how other subjects and their pedagogical

practices and praxis contribute to the shaping of scientific mindset or temper (Sarangapani, 2014). At the elementary level, the Indian education system/schooling hardly reposes any faith in the learner that she can construct her own knowledge. Most of the learning processes and procedures are 'instructional' and promote rote learning. There is hardly any space or scope for observation and analysis. We are yet to include 'problem-solving' methods in our curriculum and pedagogical framework. The introduction of science as a discipline and the attitude is expectedly left to evolve from learning the history of science rather than science at the next level. It is beyond expectation in the Indian scenario of schooling and the way curriculum is formulated that we can appreciate the Kuhnian difference between 'normal' science and the 'extraordinary' science.

We keep doing 'normal' science with an expectation that there will be a 'scientific revolutions' in Indian classrooms by miracle. The absence of basic infrastructure and laboratories is either ignored or is considered to be a non-issue for science learning. Moreover, the logical end of the study of science is expected to create professional engineers or doctors and nothing more, the applied sciences are replacing the pure sciences in higher education owing to the pressures of the market and political economy.

Conclusion

Saxena (2014) argues, "A nation where people (rulers and subjects, alike) believe in miracles and supernatural beings and powers will not understand and appreciate the developments of the modern philosophy of science; neither will it be able to progress based upon the innovations of modern science" (p 123). An individual with scientific temper does not take things at the presumptive worth, but endeavors to discover the why and how of it. One of the substantial results of the scientific temper and argumentative approach is the occurrence of liberal thought. Societies with scientific temper will prosper in the long term (Saxena, 2014).

The question of whether the scientific temper can be induced/inculcated amongst learners/people can be answered from two affirmative standpoints which we learned only by

learning science that a) anybody and everybody can learn and know and b) the education system/schooling get its legitimacy and validity only because it can bring the expected and desired change in the people. So, it must inculcate the scientific temper because we as a civilization are no more living as tribes but in a globalised world. Sscientific temper is a pre-requisite to live in such a world where one does not fear that his/her knowledge will get rejected – an attitude required to be a scientist.

The third perspective on scientific temperament is that humans are born with it and it is the stultifying education system, exclusionary knowledge domains which nip this temper of inquisitiveness and curiosity in the child by asking him/her to learn and re-learn and to learn-by-heart the prescribed text and syllabus. Only agencies that govern the scope of study in schools and prescribe the curriculum related books, need to design them such that our teaching-learning in schools leaves no scope for superstition in the minds of the students, and develops in them the power of reasoning so that when they are told about some 'miracle' they are able to critically perceive and systematically observe. As Nehru said, "What is needed is 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" (Nehru, 1946).

Fostering scientific temper will help us to address many social issues and concerns with objectivity and open-mindedness and will also help us to realize that (wo)man is a rational animal. For scientific temper is not a theoretical outcome of doing science but "Scientific Temper is essentially a world-view, an outlook, enabling ordinary citizens to choose efficient and reliable knowledge while making decisions in their individual and social domains. It is not the content or extent of the knowledge base of one or other domain of scientific corpus that a citizen acquires, but rather the pursuit of rational inquiry, which is the hallmark of Scientific Temper" (*Scientific Temper Statement Revisited 2011*).

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