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How much Scientifically Tempered we are? A question for introspection

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Abstract

This article is an attempt to conceptualize the affective trait of scientific temper in relation to nature of science (NOS). By affective we refer to the one's affect such as emotions, feelings, moods and attitudes associated with various actions one perform. The trait of scientific temper is affective in nature because its manifestation involves a constant conversation with one's self. One's temper is very much influenced by his/her dominant feelings, likes and dislikes and emotional inclination. Scientific temper is defined as a frame of mind that accepts truth in its real form without subjecting it to any kind of influence. It is observed that some individuals possess a high degree of scientific temper and some are relatively less scientifically tempered. In both the categories it holds a direct bearing to their understanding of NOS. NOS is a misinterpreted concept in school science that leads to misconceptions about science within students which persists in their later lives also. It is a varying thought process as different individuals seem to place themselves in different positions in their perceptions about NOS. A better understanding of NOS in an individual helps him/her to relate science more meaningfully in their lives. Thus the perception of NOS seems to have an impact on the trait of scientific temper. Scientific temper enables a person in making unbiased judgments and informed decisions. It holds a great significance in the decision-making process of an individual in day to day affairs. It can be said in a nutshell that societies preaching the real nature of science through the process of schooling seems to be more scientifically tempered in their outlook. However, the trait of scientific temper is operational in both scientific and non-scientific setting. In fact being scientifically tempered in our social settings has a high return value in terms of combating with various social problems. *Keywords:* Scientific Temper, Nature of Science (NOS)

The Coining of the Terminology of Scientific Temper

The post independent India under the leadership of its first Prime Minister Jawaharlal Nehru got a firm footing in the sphere of Science and Technology. The Nehruvian vision was to develop the nation by rejuvenating it through the spirit of 'Scientific Temper', a term coined by him in his book 'Discovery of India' (1946). He wrote in his book that, although science has been dominating in the western world, west is still far from having developed the real temper of science whereas India, in spite of her less triumph in the sciences, has the advantage of traditions encouraging fearless search for truth, respecting the solidarity of man, the divinity of everything living, free and co-operative development of the individual and the species, ever to greater freedom and higher stages of human growth (Nehru, 1946, pp.514-516). His conclusion was a direct outcome of two world wars fought in the recent past that ashamed humanity. It was a timely plea to

the world leaders, politicians, scientists, citizens of the times to identify the much needed notion of 'scientific temper'. In fact, India included 'scientific temper' in her constitution through 42nd constitutional amendment, 1976. It was introduced as a sub clause of article 51-A (h) of Indian constitution 1949, as one of the fundamental duties to be performed by Indian citizens which states, '*to develop the scientific temper, humanism and the spirit of inquiry and reform'*.

After the death of Nehru, the legacy of scientific temper was taken forth by the Nehru centre, Bombay which has been organizing Nehru memorial lecture series since 1966. After being framed as a fundamental duty of Indian citizen, the notion of scientific temper again came in lime light July 1981, when some group of people, mainly from the academia at Nehru centre in Bombay issued an historical statement on scientific temper. This historical event invited a lot of debate all over the country and since then a lot of thinking has been again poured into this forgotten notion.

What is being Scientifically Tempered?

The term temperament is distinctly associated with G.W. Allport, who is regarded as the founder of personality psychology. Temperament refers to the characteristic phenomena of an individual's emotional nature, including his susceptibility to emotional stimulation, his customary strength and speed of response, the quality of his prevailing mood and all the peculiarities of fluctuation and intensity of mood, these phenomena being regarded as dependent upon constitutional make-up and therefore largely hereditary in origin. (Allport, 1961, p. 34). Goldsmith and Campos (1986) defines 'temperament as individual differences in emotionality'. McCrae et.al (2000) states that there is no hard and fast distinction between temperament and personality and there are both empirical and conceptual links between child temperaments and adult personality traits. Review of literature suggests that the term temperament and personality are used interchangeably (Strelau, 1987).

Although the aspects of behavior, thought, and affect are widely acknowledged to be reflected in temperament, the emphasis has more often been on affective elements, and on biologically based traits (Saucier & Simonds, 2006)

It is evident from the above definitions that temperament is an affective construct which deals with emotionality and has a direct or indirect linkage to one's personality. It could be a possible reason for Nehru to pick the term 'temper' from the psychological construct of 'temperament'. Nehru associated temper with science synthesizing a typical trait associated with science and being a scientist. It is a required commitment and inclination within a doer of science in order to understand and apply science in both academic and societal level.

A Statement on Scientific Temper prepared by a group of scholars and issued on behalf of the Nehru Centre, Bombay, in July 1981, mentions that Scientific Temper involves the acceptance, amongst others, of the following premises: (a) that the method of science provides a viable method of acquiring knowledge; (b) that the human problems can be understood and solved in terms of knowledge gained through the application of the method of science; (c) that 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; and (d) 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 (e) that one should from time to time re-examine the basic foundations of contemporary knowledge.

Narlikar (1993) emphasized that scientific temper is the real need of the hour which guides man to rational recourses whenever there is conflict between science and tradition. One neither has to be dazzled by miracles of science nor blinded by overpowering traditions. Scientific temper is that self-correcting tendency of rational beings that helps him/her to harmonize between needs and desires. He said there are three fundamental processes operating in science which are Experiment (E), Observation (O) and Deduction (D) that keeps science going and scientifically tempered person believes in the EOD system of testing and verifying knowledge.

According to Dhar (2009), scientific temper, or scientific attitude is characterized by following traits: a)Healthy skepticism, b)Universalism, c)Freedom from prejudice or bias, d) Objectivity, e)Open mindedness and humility, f) Willingness to suspend judgment without sufficient evidence, g) Rationality, h)Perseverance - positive approach to failure.

According to Palampur declaration (2011) scientific temper is defined as 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 knowledge base of one or other domain of scientific corpus that a citizen acquires, but rather the pursuit of rational enquiry, which is the hallmark of scientific temper.

Mahanti (2013) gives a historical tracing of the concept of scientific temper in our country. He reported that although the termed was coined and used for the first time by our first Prime Minister Pt. Jawaharlal Nehru, the existence of the notion can be traced back to Gautama Buddha in Indian traditions and to social reformers like Raja Rammohun Roy, Rajendralal Mitra and Prafulla Chandra Ray. He also reports that it was our first prime minister who greatly contributed for upholding of this nation under which country's development could gain a momentum. Nehru's effort led to the adoption of Scientific Policy Resolution (SPR) of 1958 by Indian parliament which prioritized the growth of science and technology.

Gopichandran (2013) tried to emphasize on the need of the hour for nation, especially in context of launch of 12th five year plan, i.e. to instill the trait of scientific temper both in masses and educational institutions. He further said that students at all levels of learning including higher education and research should be oriented to principles of science and scientific thinking, wherein such aspects as open-endedness of insights, heuristics, emerging frontiers of knowledge based on newer and better application of tools/techniques and limits and limitations of systems of investigations and insights are suitably highlighted. It is equally important to infuse such human values as respect for knowledge systems and the spread and depth of knowledge consolidation that does not necessarily reveal the founding principles, precautionary principles and common good.

Saxena (2014) tried to pinpoint the misconception about scientific temperament (temper) within the layman because of ignorance. He suggests that educating the young in order to imbibe in them an argumentative approach to test and accept things is perhaps the only way to develop scientific temper in society.

Raza (2015) tried to compare the hazy or nebulous notion of scientific temper with the European enlightenment. He argued that scientific temper not only confines itself with areas of human cognition and action but it goes beyond the boundaries of science and extents in the realms of extra-science as well. The struggle of creating a scientifically tempered society is a collective endeavour to be strived by one and all and scientific awareness is the prerequisite for it. He cited evidence where increase in scientific information in society does not guarantees the reduction of extra-scientific beliefs. Both tend to coexist with their contrasts as long as they are not in the way of each other which is a very doubtful situation for scientific temper.

Thus in summation it can said that being scientific tempered means to accept the truth in its real form without subjecting it to any kind of influence. It is a temper of a free man (Nehru, 1946, pp.512). It is man's capability in dealing with both scientific and the non-scientific issues in the society.

The Real Nature of Science

The Nature of Science (NOS) is never understood especially in philosophical perspective in traditional school science. It is the most abstract domain of science education and hence most little dealt. NOS is an unfamiliar and alien domain in Indian scenario. NOS is a multifaceted concept that including the aspects of history, sociology and philosophy of science and has been defined variously as science epistemology, the characteristic of scientific knowledge and science as a way of knowing (Bell, 2008). Often it is misunderstood by the teachers and mis-communicated to the students leading to conceptual stigmas. This domain of science is poorly addressed in majority of curricular materials, and when it is addressed it is misrepresented (Bell, 2008). NOS acquaints student with kind of knowledge generated by the scientific community and characterize its generalizations and limitations both. The very basic NOS is that science cannot provide complete answer to all questions/problems (Eastwell, 2001). But often societies hold just an opposite assumption and have far-fetching expectations from science. Another common assumption about science is that everything which is imagined scientifically should find an experimental explanation in order to be part of scientific knowledge. But there are instances where only through imagination many probable solutions for a given problem were sought by a scientist, which was found to be absolutely valid when tested by someone else. A popular myth about NOS is that there is 'a universal scientific method' every time followed by scientists to derive scientific knowledge (Eastwell,2001; Bell,2008). This belief needs to be rectified. Whereas scientific method is most followed method in deriving scientific knowledge, there are still some parallel means like experience, imagination and intuition that may also work in order to reach certain conclusions.

The whole scientific enterprise is based on notion of 'tentativeness' which states that nothing in science can be treated as constant static truth rather it is dynamic truth. Scientific knowledge is a filtered authentic and stable piece of knowledge which is checked for its validity and reliability in multiple experimental settings. Replication of experimental setting is nothing but filtering the facts and nearing the truth. The degree of authenticity of this knowledge increases every time it is verified through truth filters. Scientific knowledge is some time subjective but its subjective nature can be translated

to objectivity by perseverance i.e. through repeated trials. Science seeks subjective clarification although it is objectively conceived. Science is not a solitary pursuit (Eastwell, 2001) rather a collective and cooperative endeavor and a valid scientific explanation may not be possible in a standalone platform. Science is value free but technology which is a companion to science is value laden. It is associated with some goodness or badness about it; and hence technology is not science (Wolpert, 2002). Technology makes scientific principles, theories, and laws workable and usable but science is far more than a technological enterprise. Perhaps in Indian educational setting treating science as technology is the biggest misconception about the nature of science held by students and teachers. NOS is not part of science curriculum in our country which leads to inadequate understanding about science within the school students. Students fail to utilize the scientific knowledge in their own lives because they are never exposed to the notion of NOS. The problem emerges because of lack of harmony in between scientific methods and process skills in science teaching. The science laboratories are often overloaded with miniature practical replicas of experiments having no time for discussing the kind of process skills required for doing science. This creates lot of confusion and tension in the minds of young learner who might find learning and doing science bit abstract. Students are taught what to explain but not how to explain, they are taught how to reach a particular conclusion through an observation but not what they can infer from observations and its background; students are taught about forward approach of experimenting and concluding and not much about backward approach of designing a new experiment based on permutations and combinations of available facts. This is how students are introduced to the NOS, at least till their secondary level of schooling in our country. This characterizes science as being abstract, hostile, difficult, serious, not fit for all, which is not the real nature of science. Bell (2008) highlighted the importance of science process skills in order to understand the nature of science. Science process skills can be taught to students right from their elementary science lessons, thus can become a potential tool in teaching the NOS. Doing science at any stage of schooling has a direct bearing to basic process skills like observing, measuring, classifying, inferring, communicating, prediction and higher order integrated process skills like hypothesizing, investigating, controlling, and experimentation. It thus has an indirect linkage with NOS. This leads to a thought that non-misinterpreted knowledge of NOS enables a student of science and even the non-science students to rightly relate scientific knowledge with their lives. The task of the teacher is to provide clarity against some popular myth about NOS. Students should be well aware about real nature of science, in absence of which they might not be able to understand the real essence of doing science.

The Relationship between being Scientifically Tempered and Understanding the Nature of Science (NOS)

An analysis of characteristics of scientific temper and nature of science suggest that there is some overlapping characterization. It is explained as follows:

It is believed that students ‘understanding of science’ as a ‘way of knowing’ is absolutely necessary if informed decisions are to be made regarding the scientifically based personal and societal issues that increasingly confront them; such decisions necessarily

involve careful evaluation of scientific claims by discerning connections among evidence, inferences, and conclusions(Zeidler et.al., 2004)

A popular myth about NOS states that everything can be proved using scientific method alone. Scientific method is an amalgamation of inductive and deductive method. There is debate in scientific community over the superiority of one over other. It is just like egg and chicken puzzle asking which came first. However, there is no fixed method but 'trial and error' method is the heart of any scientific expedition. Even in primitive times the discovery of fire or the invention of wheel was an outcome of trial and error. In both inductive and deductive methods there is commonality of evidence. 'Evidence' is observable by our senses and inferable through logic. Scientific temper can be equated to application of the scientific method based on logic and evidence (Palampur declaration, 2011). A scientifically tempered person therefore looks for evidences to judge any situation. He/she tries to evaluate things, situations and circumstances in the light of evidence. The history of science reveals both evolutionary and revolutionary changes where with new evidence and interpretation, old ideas are replaced or supplemented by others (National Science Teachers Association, USA, 2000). A scientifically tempered person similarly revolutionary in his ideology and is more open to a change. He/she resorts to trial and error frequently before coming to a conclusion.

A second point of overlap is provided by finding an answer to the question that should we rely on facts or methodology of doing science. NOS advocate the importance of process over content. Mere content which enables us to answer 'what' and not 'how' are misleading for students of science. According to Dewey (1916) understanding scientific method is more important than acquisition of scientific knowledge provides a support system to any person in taking scientific decisions. A scientifically tempered person tests the factual knowledge for its validity and does not simply believe on any propaganda or statement. He/she applies the process of sciences to derive meaningful conclusions. The open mindedness of a scientifically tempered person guides him/ her to perceive reality keeping space for required adjustments as and when required for accommodating whole truth than partial truths.

Thirdly, we feel that proper analysis of contexts are very important in any decision making process. Seeing things through the lens of context is an outcome of post-modern thought process which asks whether science is interdependent with or independent of cultural context. For e.g. there are instances in the history of science when some scientists never gave up their faith in a particular theory which they claimed to be true and tried to adhere to it. Such claims were rewarded much later for their truth, sometime even posthumously. Our immediate surroundings, contexts, frame of references are our first teachers. Our contexts shades our imagination and give rise to our ways of thinking. There is nothing wrong in being contextualized and the real NOS appreciate its significance. In recent times the local ecological knowledge and the tacit knowledge has been acknowledged for its benefits which is nothing but contextualized knowledge. Lack of rigidity in the attitude helps a scientifically tempered person to be more adaptive to changing times. He/she sees things in light of contexts and rely on holistic inferences and not single observation.

Finally, there is a central question, whether science is all about providing ideas which are workable or science is just a knowledge expedition, whether it is works or not is a matter outside its purview? Wolpert (2002) raised a similar question, whether scientists are for application of science? He answered this question by saying, this is neither possible nor should be expected from scientists. Scientists just search truth and in course of doing so some time through serendipity, or by curiosity some unexpected outcomes take place. A scientist cannot predict the future outcome of his discovery or invention. The real problem comes when a scientific finding is applied in public through technology, which inherently comes with ethical issues (Wolpert, 2002). The real nature of science is honest inquiry where a scientist is not held responsible for the unpredictable consequence of a scientific finding. The very nature of science is that it is not possible to predict what will be discovered or how these discoveries could be applied the most apt example being that of cloning (Wolpert, 2002).Science is neither good nor bad but it is its application which makes it good or bad. Man is a moral being and it is his decision making that decides the course of science. Wolpert (1992) defines 'openness' as one of the most characteristic features of science, along with allowance for controversy and public access to knowledge. Technology, by contrast, he presents as a style of thought that promotes secrecy and thrives in recipes and opaque (pre-scientific) procedures. Thus issue of morality and ethics is involved with every application of science made possible through the technological enterprise. Technology on one hand depends on science and on the other hand paves the path for future scientific endeavor. While science and technology do impact each other, basic scientific research is not directly concerned with practical outcomes, but rather with gaining an understanding of the natural world for its own sake (National Science Teachers Association, USA, 2000). Hence reliable scientific knowledge is value-free and has no moral or ethical concern. In light of this conception the nature of science is very unpredictable and a scientifically tempered person knows how to judge a scientific discovery or invention in the light of morality. For e.g. a person with such temper will surely choose to technologies which are environmental friendly such as biodegradable, pollution free, natural, cost effective and efficient. A very apt scenario of ignorance of scientific temper is presented through the plot of Gulf war where massive resources of oil fields in a gulf nation were destroyed by another nation just to win a battle, which was fought keeping the interests of total world population at stake. Natural resources are commonly shared inheritance of all the human beings in terms of economic equality, but sadly very few nations own the maximum resources of the world. There is a fine line difference between being intelligent and wise. This is very well explained by Sir Bertrand Russell, a great philosopher, mathematician, scientist and social reformer,

"We are in the middle of a race between human skills as to means and human folly as to ends…….Unless men increase in wisdom as much as in knowledge, increase of knowledge will be increase in sorrow."

A person with scientific temper knows that being realistic, providing unbiased reality, with no hidden agenda or component of secrecy is real NOS. He/she knows that sometime all the answers cannot be provided by instrumental approach of science. Scientific temper in people enables them to suspend judgment through accuracy in

thought and action. They need to know the situation through an independent unbiased perspective and then judge it. Being unbiased is a key trait of NOS and scientific temper both. The trait of scientific tempered highlights the natural tendencies of children but as they grow, the degree of its effectiveness tends to decrease owing to constant molding through school science which somehow has been the main vehicle to propagate myths about NOS. As a result students fail to distinguish between science and technology, they believe that there is one universal scientific method which is followed by all scientists and that the scientific truths are unchangeable. Knowledge of NOS enables a person to distinguish between science and technology which in turn helps him to take informed decisions on the acceptance or rejection of a technology. If we as science educators wish to cultivate future citizens and leaders who care, serve the community, and provide leadership for new generations, then we have a moral imperative to delve into the realm of virtue, character, and moral development (Zeidler et.al, 2004). There is a guiding value system in built in nature of science that helps citizens to take informed decisions. What is required out of the process of schooling that children should be introduced to real nature of science and safeguard them from popular myths held about NOS.

Conclusion

It will be a mistake to call an age a scientific age just on the basis of the accumulated mass of scientific knowledge. An age can be called as scientific when the problem of society can be faced and handled by men with scientific temper (Jahagirdar). Through its emancipatory nature, science liberates us from the bondages of superstitions, bridges the gap between different strata of society, and has the potential to solve all the problems of mankind. In contrast, the same science can be mishandled and made oppressive through politicization and power play. The benefits of science like modern medicine, means of comfort are not equally accessible to all. It leads to new plot of disparity. This plot is very nicely narrated in the words of Nehru, “To-day, in the world of politics and economics there is a search for power and yet when power is attained much else of value has gone. Political trickery and intrigue take the place of idealism, and cowardice and selfishness takes the place of disinterested courage.” (1946, pp. 560). The main question of concern in 21st century is how much scientifically tempered we are? Are we prepared to choose between right and wrong, just on the basis of our training in science or we need something more than that?

It is very evident that real nature of science enables a science student to better learning experiences in science. Also it is through knowledge of NOS students are able to identify themselves with science in holistic perspective through the lens of history, sociology and philosophy of science. They find it more convictional and adaptable in their daily affairs. A scientifically tempered person possesses a mind-set that uses scientific method as a way of problem solving in his/her day to day life. If he/she knows the NOS well, he or she can do more informed decision making. Such people are more rational in their approach. Societies preaching the real nature of science through the process of schooling seem to be more scientifically tempered in their outlook.

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