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RESEARCH ARTICLE

Understanding Scientific Temperament and Assessing its Social Relevance

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ABSTRACT

Most people have wrongly understood scientific temperament. Though efforts have been made for long to inculcate scientific temper and rational thinking among the lay-public, it has largely been an unsuccessful attempt. One of the major factors may be the tendency of society to submit to every belief and viewpoint of our ancestors, without ever testing its feasibility or its relevance in the changing times. Educating the young can have a positive effect on development of scientific temper in the society. Students should be encouraged to reason and argue with their teachers, mentors, and elders in a healthy manner and should employ a do-it-yourself approach in analyzing situations and solving problems. They should also be encouraged to read the ancient texts in order to critically analyze them and accept or decline the claims that they make based on one's rational thinking.

KEYWORDS: Scientific temperament, Argumentative nature, Curiosity, Atheism, Social evil, Superstitions

Introduction

Scientific temperament has often been mistaken by common people as a concept far removed from reality, which is only important to the scientific community. Scientific temperament can be defined as a state of mind where a man or woman makes decisions (both, big and small) and acts according to a rational belief system, which can be tested and validated as and when required by mathematical modeling and/or experimentation.

The scientific community as a term used here refers to people involved in a specific research and development based career and thus unravel the way in which the universe (including galaxies, stars, planets, the people of this world, other life forms) evolved and try to predict and wherever possible, modify these systems in order to come up with innovative products or just for furthering their understanding of the nature and the universe. For the purpose of this paper, the layman or the common man is defined as all other people that lie outside the above definition of scientific community.

The critics of scientific temperament have maintained that scientific temperament or temper is not realistic enough to solve the day-to-day emotional needs and that science has reduced human feelings and emotion to mere molecules that function according to laws that can be theorized on sheets of papers. But, such critics have not been able to understand scientific temper in its entirety. Scientific temperament is in fact a way of life. It teaches you to observe and test before forming any hypothesis or a perception about anything going on around us and it requires the repeated verification of the hypothesis by laboratory-based experimentation or by obtaining mathematical or statistical models or analyzing survey results, etc. It trains us to believe in ourselves and learn on the basis of real observation and argument rather than the archaic concept of trusting the authority on each and every thing.

Change is important and inevitable, and scientific temper enables us to change what cannot be verified. It is important that we should be willing to change certain rules, laws, traditions, etc., which, however deep rooted in our culture, have caused degradation of the society or have not been able to prove their efficacy after repeated tests and experiments. Scientific temper is important for the development of a nation in all spheres *viz.* political, economical and social. An important way in which our political system can benefit from scientific temper is by working "for the people" and staying away from using the emotional and communal stick to force people into voting for a particular party.

Scientific temperament can in many ways form the basis of what has been called "developmental politics" by Dr APJ Abdul

Kalam at various places in his book *Turning Points* (Abdul Kalam, 2012). This also shows that scientific temper and scientists are not against society or humanity, they just suggest ways of testing and validating our long held beliefs and the way in which we want to live in our country and the society. Societies that are scientific in temper and believe in developing technologies indigenously will prosper in the long term. A lot of people from all walks of life (unfortunately including intellectuals) have often argued that in a country where people do not get food, scientific research need not be paid attention to. Ambitious technologies such as space and defense research have often borne the brunt but even much more conservative sciences like modern agriculture, pharmaceuticals and biotech too are affected. I would like to argue that for proper development of the society and the nation, we divided various sectors and each sector should do its own work. Scientists do science and if the country lacks an effective food distribution system, or if poverty and malnutrition have not been uprooted in the country, scientists cannot be blamed for using the public money and coming up with nothing. Science does not provide magical solutions, it needs to analyze the data (already available and freshly generated) and come up with probable solutions. The implementation part is for the government agencies to take care of. In short, you cannot and should not blame the moon mission for people going hungry or dying of disease. In any case a rocket scientist or an astronaut can do little to end hunger in this country. A rational society with scientific temper would question and criticize the right authorities for their problems.

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. The first Prime Minister of India Pandit Jawaharlal Nehru was a firm believer in the concept of scientific temper and he held that “no country or people who are slaves to dogma and dogmatic mentality can progress”.

As argued by Dhar (2009), scientific temperament or temper (scientific attitude) is characterized by following traits:

1. Healthy skepticism
2. Universalism
3. Freedom from prejudice or bias
4. Objectivity
5. Open mindedness and humility
6. Willingness to suspend judgment without sufficient evidence
7. Rationality
8. Perseverance — positive approach to failure

Apart from these eight points, I feel that scientific temper or attitude calls first of all for keen sense of observation and an inherent curiosity. A person with scientific temper does not take things at the face value, he/she will always try to find out the 'why' and 'how' of it. The attitude of a person with scientific temper should not be passive (the so called '*chalta hai*' attitude). Surprisingly, it appears that the scientific temper and the pro-active attitude towards problem identification and problem solving (including designing innovative solutions) has got nothing to do with whether a person is from rural background or urban background. In fact, one is surprised to learn that artisans from village and small towns are much more pro-active towards innovations and problem solving approach (Bhat, 2011), even with limited, or in most cases, no education at all. This is quite counter-intuitive and can only be attributed to their keen sense of observation and curiosity.

Scientific Temper and Society

In the perspective of the society, scientific temper and the argumentative nature might help us to understand the philosophies of modern, medieval as well as ancient times, analyze them critically and follow the rational ones. All philosophies of any given era are only partially rational. As modern science has progressed, some of the philosophies have been converted into 'doable sciences' and have reaped benefits for mankind; others may still be waiting to be proved rationally using mathematics or experiments.

All philosophies and belief systems come with their own load of superstitions. When we talk about superstitions, our

society is full of them. Faith in an almighty might seem fine from the perspective of the primitive being. In fact, the ancient man was good at observing and reasoning and was reasonably argumentative. Several old Indian texts like the Vedas, the Mahabharata and the Ramayana testify the argumentative nature of ancient Indians (Sen, 2005). It would not be wrong to say that man 'invented' the concept of the supreme intelligent being or the creator or almighty. In accordance with the stage of his mental development he invented a wonderful idea of explaining certain phenomena of the nature. But like all things invented by humans this concept has begun to age and lose its relevance and needs to be modified and polished (or in some cases thrown out all together). It should be kept in mind that human inventions, however attractive they may seem, are static in space and time (Nehru, 1946), it is the case with all social practices, beliefs and traditions. Pt. Jawaharlal Nehru says in his autobiographical work *Discovery of India*:

> "It may be that we of this modern age, who so pride ourselves on the achievements of our times, are prisoners of our age, just as the ancients and the men and women of medieval times were prisoners of their respective ages. We may delude ourselves, as others have done before us, that our way of looking at things is the only right way, leading to truth. We cannot escape from that prison or get rid entirely of that illusion, if illusion it is."

Certain social practices if studied in detail will bring to light their futility and the fact that they are not based on any hard facts, rules or law that benefit the society. An example can be the very basic and widespread practice of praying to an 'almighty'. With so much advances in the understanding of physics, the origin and the evolution of the universe, the nature of matter and that of the fundamental forces of nature, and the developments in modern biology resulting in a revolution in medicine and biotechnology, the idea of god as a creator and the protector of the universe and hence of our world and prayers being the way of pleasing 'him', have become irrelevant. Yet millions in our country, in fact in the whole world still believe in a divine being.

The concept of atheism has been demonized and projected in bad light ever since the ancient times without really understanding it fully.

Right from the time when Francis Galton dared to question the efficacy of prayer in 1872, there have been several studies for testing the efficacy of prayers and the results have failed to produce a clear link between prayer and the achievement of desire or blessing being asked for fulfillment. There's a lot of confusion related to studies on such topics, sometimes because the approach is not very right. Until we are able to establish a one-to-one cause effect relationship between prayers and fulfillments and we can predict the exact or at least probable mechanism in which the wish is fulfilled or blessings granted, it should be considered a mere coincidence. The fictitious study by Robert Ehrlich (2010) to test the effectiveness of intercessory prayer can be taken as an example of yet another attempt to study the effect of prayer on the health of people of various religions. Though the design looks good (and even if it is fictitious) it lacks some important controls *viz.* patients for whom no medical treatment was available and only prayer was done and another group where the best medical treatment was given but no prayer was done.

Had there been an omnipresent omnipotent god who has been there forever, other forms of life also must have formulated the concept of Supreme Being. Apparently there have not been any significant studies where other life forms, say a bacterium, or plankton or a fish or a bird or whale, dog, elephant, horse, etc. have been tested for the existence of a concept of god or a fear of the supernatural.

More interestingly, leaving the ancient Egyptians and some other prehistoric cultures, god has always been given a human figure and has been talked in terms of qualities and adjectives that are human. Barret & Keil (1996) have beautifully explained why humans tend to talk about supreme beings yet end up anthropomorphizing them, with the help of innovative studies.

Talking of strange religious practices, another example is of a temple in the state of Rajasthan in India, where rats consume the milk offered to the deity first and then that is distributed as

prasad to the faithful devotees. It is said that there is no disease or ailment that afflicts the devotees. However, one must bear in mind that no formal studies have been done on the effects of consuming the milk tasted by rats on the devotees. And even when someone suffers from illness, of which the numbers might run into at least a few hundreds, there is always the age old explanation that happens to be the last nail in the coffin of most intellectual arguments: god's will.

Other superstitions include trusting in god-men, horoscope readers, believing in witchcraft, occult, etc. Such a culture has been holding ground in our society because in the past, due to certain coincidences in far away and rare cases, superstitions might have been held true. For example, if once, twice or may be even 100 times in a vast spatiotemporal span, sneezing would have adversely affected the subject going for some important work (say an exam or a job interview), it does not imply that sneezing before leaving for an exam or interview causes bad luck. Astrology (and allied cultures *viz.* numerology, color therapy, gemology, palmistry) may just give the subject peace of mind but they do not give solutions to ones problems. Stars and planets exert just gravity on every other matter in the universe (including man), they cannot do anything else. They just cannot determine when one will die or what one will choose as his/her career or life partner, etc. Justice Jahagirdar whose thoughts have been published by Rationalist Foundation writes about scientific temper and chides astrologers and godmen for taking the common people for a ride.

The occurrences of sporadic cases should not be considered as general laws that they are often taken to be, because there is no repeatability and reproducibility in the way they affect people's life. Also, the numbers of people that get the desired results by abiding to (or avoiding) these superstitions (as the case may be) are insignificant.

It is a common observation that rural communities get affected by superstitions and practice social evils in the name of tradition, to a much higher level than the urban and cosmopolitan communities. Although this observation might be true, while comparing the education of urban communities should be taken into account. When one starts thinking along these lines, the

irony that the educated city dwellers believe in superstitions and social evils even after all their education and "rational thinking" becomes prominent.

Sometimes, very basic social behaviors and thought processes can bring forth the lack of scientific temper in even the most highly educated. The so-called educated middle class is proud of its education and rational thinking but scrap the surface a little and there we find the age-old beliefs that have not been validated and social malpractices still being thought as right by them. The reason? Hierarchal authority and fear of change.

Every day one comes across millions of middle class Indians who see various '*gurus*', palmists, astrologers, etc. Middle class people who studied the *Theory of Natural Selection through Evolution* and the *Big Bang Theory* as part of the school curriculum throng temples, churches and mosques in the hope that a supernatural force is governing their lives and everything happening around them and will solve their problems. Why this disregard for basic education? Mahanti (2013) quotes Narlikar:

> "Today we live in a free India that is feeling its way towards economic prosperity. Yet we are still a long way from achieving that scientific outlook which Nehru considered so essential for our future wellbeing."

He says that despite including the development of scientific temper in the policies of the governance not much has been achieved. Scientific temper and argumentative approach is linked to the very idea of democracy and the idea of equality. It is common to see people having preconceived notions about people of other castes or religion or the prejudiced way in which females are treated in the predominantly male-dominated society. Also very common is the way people treat inter-caste marriages or the concept of widow remarriage.

Scientific temper can help us to understand and rectify these social evils or rather misconceptions in a two-pronged manner; first, employing a hypothesis testing approach to actually validate the relevance of the false (or true) notions and prejudices held by people. For this, field research studying a small community or group of people that is nonetheless statistically significant in number must be performed and the

results analyzed. As an example, a recent paper by Moorjani *et al*., (2013) showcased their findings establishing that endogamy in the Indian subcontinent started much later preceded by a vigorous and proper population admixture between the sections of two large groups ANI (ancestral north Indians) and ASI (ancestral south Indians). This study, in its wake shows that endogamous marriages that we believe on moralistic and social grounds as an Indian concept did not exist, even during the early *Vedic* period, and it also shows that various groups of Indian population might have been derived from the same *Caucasian* or *European* stock (a good example being very close relatedness between *Brahmans* and *Shudras*!). The second way in which scientific temper would help is by making people understand the results and then separating the myths and misconception from facts.

Several researches indicate that the *jati/varna* division that prevailed in ancient India was more on the occupational and economic basis rather than on the basis of birth or family. Modern studies by anthropologists, linguists and even geneticists have proved that most of the ethnic groups in the world have arisen from the intermingling of people from various regions although not in the precise manner in which we understand presently. For example, when we talk about falsification of Aryan invasion theory, it is well understood now that the various caste, creed, etc., are Indian concepts that are relevant only socially. The *Shudras* are not genetically distinct from *Brahmins* or *Kshatriyas* (Metspalu *et al.*, 2011). But still it is important to understand that movement of people to and from the Indian subcontinent (not necessarily through an invasion) was common. Also the languages evolved on mixing with each other, but their origin might be the same (Gray & Atkinson, 2003). Thus, it should be understood that we all have arisen as a result of mixing of genes, which in turn is a result of the intermingling of races over a long period of time (not a dramatic invasion and massacre by a foreign race).

Leaving aside the mythological basis of advent of various ethnic groups in India, all people, proud of being a part of this diverse nation, should understand the importance of intermingling of races. Many of us are in fact a result of inter-

caste marriages or alliances (forced or by choice) prevalent in ancient India (Moorjani *et al*., 2013). Besides, it's well known to all the students of genetics and breeding that mixing of 'far off' genomes will show more beneficial traits in the progeny than the mixing of 'nearby' genomes. Most researches show that consanguineous marriages show defects that are congenital in nature, an increased incidence of deleterious mutation, short height, etc. (Morton *et al.,* 1956; Tayebi *et al.,* 2010; McQuillan *et al.,* 2012). Some groups have shown that alliances between close relatives have resulted in extinction of entire families. Such reasons have been attributed for extinction of royal families too, for example the Spanish Habsburg family (Alvarez *et al.,* 2009).

Attempts to Familiarize Indian Common Man with Scientific Temper

An environment of decay and stagnant thought that was caused by blind and ill-informed teaching of the Vedas by the *Brahmins* over a period of time was challenged by Siddhartha Gautam (the Budhha). He promoted agnosticism and rational thinking. Mahanti (2013) quotes Budhha's *Kalma Suta*:

> "Believe nothing merely because you have been told it or because you yourself imagined it; do not believe what your teacher tells you merely out of respect for the teacher. But whatsoever, after due examination and analysis, you find to be conducive to the good, the benefit, the welfare of all beings that doctrine believe and cling to, and take it as your guide."

In the more recent past Swami Vivekananda, Raja Ram Mohan Roy and others advocated scientific temper and fought social evils by bringing in western thought. Raja Ram Mohan Roy even opposed the setting up of a Sanskrit college by the British. Some people might see this as an attempt to put Sanskrit as a language in a bad light. However, Roy's reason was that Sanskrit education that has been devoid of innovation, research and modification might actually be detrimental to the nation in the long run (Mahanti, 2013). Others like Prafulla Chandra Ray challenged the '*shastras*' and believed that stagnation in reasoning was linked to a submission to the '*shastras*' as the

supreme guiding principles, which obviously they were not (Mahanti, 2013).

Liberal Intellectualism: An Open-minded Approach Resulting from Scientific Temper

One of the most important results of scientific temper and argument-based life style is liberal thought. As usual there are many points on which liberal thought has been criticized. The right wing and the left have often wrought brutal blows on liberal thought. When I say 'right' and 'left' I am not necessarily talking about political affiliations but about way of thinking.

Scientific temper does not lead to liberalism or liberal intellectualism *per se*, but it helps a person to equip him/herself with the tools required for liberal thinking. The most important of these tools is having an open mind and unbiased point of view. Liberal intellectuals are easily identified by their quality to accommodate most kinds of thought among themselves and also by trying out new schools of thought. They have a wonderful quality of defending all thoughts and giving justification for ideas, beliefs and practices that are uncommon or unheard of, yet prevalent in the society.

Critics have attacked liberal intellectuals by nicknaming them 'the devil's advocate'. This is a result of occasional over justification of a particular way of thinking or a belief or practice by such liberal thinkers, that the society sees as unnecessary. However, if the justification is based on a careful hypothesis testing approach and has been validated many times by various people using similar approaches, there is no harm in actually justifying a practice or its abolishment, as the case may be.

Scientific Temper in India: Indigenous Philosophy or Western Import?

In his collection of essays *The Argumentative Indian*, noted economist and author Amartya Sen talks about the ancient traditions of argument among Indians. This argument often gave way to curiosity, skepticism, hypothesis making and testing,

which are important traits found in a person with scientific temper. The ancient Indians started understanding the nature and their surroundings as well as the social environment in which they lived. Ancient literature like the *Vedas*, when studied with an open mind and in their proper context, tell about the scientific and the then modern thinking of the people (Kosambi, 1964). Although the *Vedic* period was characterized by a male dominated society (Kosambi, 1964), women in the ancient society were treated with respect and had their say in matters of state and also studied the sciences and arts. The various literature available from the *Vedic* period is full of examples which might show the actual high position of women in the society or at least a constructive attempt by the poets and bards of that era to raise the position of women in the society. In any case the ancient society felt the importance of the high position of women for the betterment of the society as a whole. Shukla (2012) mentions that works by Patanjali and Katyayan show the high position and independence characteristic of the women of that era. She also talks about women sages like Gargi and Maitreyi, showing that some women were highly educated. French Indologist and author Alain Danielou writes in his book *While the Gods Play* that the pre-Aryan civilization of India was even more scientific in their approach to life. Ancient philosophies like Lokayata (of Charvak and his disciples) were inquiries into the actual nature of the world around us. The followers of Lokayata philosophy saw the human mind as part and parcel of the human body and not as some separate entity that could have an independent existence from the human body. They acknowledged only the material human body and the material universe around it. They rejected sacrificial gifts and offerings for the after-life as was common amongst followers of Brahmanical Hinduism during the time of Medhatithi in 900 AD (Positive Atheism, 2000).

Ancient works by pre-Aryan philosophers include among others, Lokayata (the peoples' belief; taught by Brihaspati), Samkhya (cosmology; codified by Kapila), Nyaya (logic, taught by Akshapada), and Vaisheshika (physics, codified by Kanada) (Danielou, 1987). Although Danielou's claims regarding Aryan Invasion and some of his beliefs have been scientifically proven

wrong, still his interpretation of these philosophies is an eye opener, especially to all those who believe that scientific temper and argumentative nature are western contamination and were never taught by the ancient Indians to their younger generation.

By their standards ancient Indians (especially the pre-Aryans) were a very open minded and forward people but they made one big mistake, which essentially has been repeated over the years till now. They never taught the next generation to form their own ideas and question the established facts. This practice combined with the coming of the Caucasian and European groups in India (definitely not as an 'invasion' but possibly small and numerous struggles between natives and new comers), who were actually agriculturists and did not possess a system of writing till they developed Sanskrit, and were very social, weak hearted and emotional, as it appears by reading Danielou (1987), could not fully appreciate the atheistic, individualistic and scientific philosophy and way of living of the pre-Aryans. In fact, it became a practice in most Indian households for the children to follow their parents and grandparents in their occupation as well as their social outlook and behavior. It was seen as a taboo, a wrong practice and as a notion of disrespect, to ask the elders or challenge the *panchayat* or the king or the priest.

Slowly, this habit started degenerating the society, people went into their shell and chose that it was better to follow whatever was being told to them rather than challenging the king or other social authorities. Exact date of this change of philosophy cannot be tracked but it can be said since the coming of the *Vedic* people from Caucasus and from then on with each wave of immigration in the subcontinent, the rigidity of beliefs has become stronger and stronger. This may have been a response in order to protect the intrinsic knowledge and philosophy from the new comers and invaders but this approach has backfired which has become evident from stagnation in philosophical and scientific development and a degradation in the ways of living life due to 'over-moralistic' and 'rightist' approach of the social authorities.

Scientific Temper for Development of Nation: Inculcating Rational Thought in Children

According to Bhargava, quoted in Mahanti (2013), the backwardness of the nation can be attributed to lack of scientific temper, to a very large extent.

Pt. Nehru in his autobiographical work *Discovery of India*, talks about reviving the old spirit of inquiry and scientific temper in the 'new' India (Nehru, 1946).

> "We have to revive the passion for the truth and beauty and freedom which gives meaning to life, and develop afresh that dynamic outlook and spirit of adventure which distinguished those of our race who, in ages past, built our house on these strong and enduring foundations."

Nehru's dream of scientific temper being a way of life for a nation has been lost somewhere. Despite a lot of development on the science and technology front in the country, scientific temper and rational attitude seem to have eluded the masses of the nation. The fault must have been in the way science and even other subjects are introduced and taught to the children. In a recent article in *The Times of India* (Ghosh, TOI, August 25, 2013) renowned rationalist Sanal Edamaruku is quoted as "we want our kids to have top marks in maths and science but we don't ask them to lead scientific lives". Why this fear of religion, the society and authority?

It is very important to educate the young minds in the right way in order to teach them the importance of scientific temper. Such a training of young minds should begin at the very formative years of the child's education rather than towards the end of his/her school education (that does not in any way imply that it should not continue through the high school into the graduation level and even higher), as is the commonly held view.

Several studies, while asserting that teaching scientific inquiry and applying it to other disciplines than just teaching of science is important, have elaborated upon the difficulties encountered (Anderson, 2002; Khalick *et al*., 2003). A lot of

these difficulties arise because of the indigenous and individual ways in which regions, societies and teachers in these societies view science and scientific method (Khalick *et al.*, 2003). What the teachers understand, they pass on to their students thus forming the students' views about science and scientific attitude and scientific methods. As has become clear by other studies, science often is taught by making it look like dogmatic and/or full of theoretic rhetoric (van Mannen, 1977; Hodson, 1985; Cobern, 1994). It must be stressed here that we must try and project science (and scientific temper) as a tool to liberate the student from dogmas of society and religion and must do whatever it takes to prevent science from being projected as the very image it is supposed to eliminate.

The focus should be on the *do-it-yourself* kind of education or project-based learning. Often times the students are taught by the teachers in a mundane and authoritative way where they are expected to believe in and learn what the teacher is telling them. This leaves very little space for cross-questioning and doubt clearing. Moreover if the teacher is too much authoritative it makes the child submissive and kills his/her inquisitiveness. As in the households, in schools too proactive, inquisitive students are seen as disturbing elements for the class and in some cases such behavior is tabooed.

Changing these widespread practices may be very tricky but we must always try. Learning by way of activity is really an important way of inculcating scientific temper and problem solving abilities in children. Pioneering biochemist and science policy advisor Bruce Alberts had talked about imparting correct science education in schools. He firmly believed in the concept of activity-based learning and even illustrated the concept by doing a small experiment with kindergarten students. Basically, the kids were asked to identify and differentiate between seeds and dirt particles and prove their basis of differentiation or the 'hypothesis', in this case, by planting the seeds as well as the dirt particles and seeing from what the saplings grew (Sunil, 2009). In this way the children learnt about the seeds and what comes out of them in an interactive way, much better than if they would just have been told by a teacher: what are seeds and what are dirt particles?

Another important aspect of such an activity is that the child at a very young age understands that a seed is a seed not because the teacher told him/her so, but because a plantlet comes out of the seed when it is sown in the soil and water is added. Hence, by activity-based learning the children can learn about the true reason of why something is the way it is.

The above discussion may be summarized in a quote by the Chinese philosopher Confucius: *I hear and I forget, I see and I remember, I do and I understand.*

Students in advanced stages of their education like graduate and post graduate students should also be encouraged to participate in field trips and ask questions, however trivial they may seem. At this stage, a student of science (or any other discipline) must follow the advice from physicist and educationist Richard Fynman (excerpted from a talk presented at the fifteenth annual meeting of the National Science Teachers' Association, New York, 1966; available at: http://www.fotuva.org/feynman/what_is_science.html):

> "Science is the belief in the ignorance of experts (….) a man cannot live beyond the grave. Each generation that discovers something from its experience must pass that on, but it must pass that on with a delicate balance of respect and disrespect, so that the (human) race — now that it is aware of the disease to which it is liable — does not inflict its errors too rigidly on its youth, but it does pass on the accumulated wisdom, plus the wisdom that it may not be wisdom.(….) teach both, to accept and to reject the past with a kind of balance that takes considerable skill. Science alone of all the subjects contains within itself the lesson of the danger of belief in the infallibility of the greatest teachers of the preceding generation."

A practice of teaching from research papers may help the students in many ways. Books, though they are very helpful in understanding the basic concepts and are a good way to keep all related information about a topic at one place in a concise volume, are actually 'static' sources of knowledge. Research articles (especially a good collection of old and new), on the

other hand can help the students by introducing them to the origins of a research problem, the initial attempts to solve them, designing of experiments and problems encountered, etc. (Sitaraman, 2011) in an organized and well laid out manner.

Students can take books to be resources that are full of information yet mundane and may not want to explore them properly; however, research paper reading triggers thinking abilities of students as they learn to make sense of each section (abstract, introduction/hypothesis building, methodology, results and discussion/justification). They have to read a research article very carefully and somewhat imaginatively (Sitaraman, 2011). This also makes the student able to write research articles on his own.

Effective models for making students understand important concepts can be a good way to teach. Later the students must be encouraged to apply the knowledge gained by studying one model to another similar situation and infer the results. They can further analyze the differences and similarities between the model and the other situations. This 'extrapolation' of concepts actually helps the students to develop scientific temper by allowing them to think freely, accept or reject ideas and hypothesis and find reasons and answers for what they read or observe, on their own.

Examples from ancient texts and old scientific principles and beliefs can be given to students. This will teach them to appreciate the scientific method and nuances of doing research in their everyday lives for their everyday needs, while also teaching to appropriately test and criticize old scientific knowledge. Later, the students can analyze the belief or the hypothesis and form their own notions about them (with reasons obviously). Critical and thorough study of the old or rejected concepts can still help the students to learn to use scientific method of doing things and help them to get used to the scientific rigor which can help them in their lives irrespective of their profession. Sitaraman (2008) used such an approach with his master's programme students. While Molecular and Cell Biology is a routine paper in most of the undergraduate and graduate level Biotechnology programmes, his introduction to Schrodinger's book *What is life?* and to the theory of *Vitalism*, made the students learn about

the basis of reasoning and rejection and the continuous spirit of reinvention in the learning of science.

Conclusion

Scientific temper and scientific method have often been attacked for being too objective from the perspective of the society and the common man. To some extent it is, and there is nothing wrong in its being so. Here I have tried to bring out the basic tenets of scientific temper and how the lack of scientific temperament and argumentative approach has brought about stagnation of thought and degradation of the society. I have also highlighted the importance of curiosity and the 'testing and rejection' approach of reasoning and how can it help in our life by taking us away from superstitions, social evils, and prejudices towards development and equality, and make us a rationally thinking free society. In the last section I have suggested giving the right kind of education in the right manner as a probable way of spreading scientific attitude in the society.

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References

Abdul Kalam A P J (2012) Turning Points: a journey through challenges (1st edition), Harper Collins India.

Alvarez G, Ceballos F C and Quinteiro C (2009) The role of inbreeding in the extinction of a European royal dynasty, *PLOS On*. 4 (4): 1-7.

Anderson R D (2002) Reforming science teaching: what research says about inquiry, *Journal Science Teacher Education* 13(1): 1-12.

Barrett J L and Keil F C (1996) Conceptualizing a non-natural entity: anthropomorphism in God concepts, *Cognitive Psychology* 31: 219-247.

Bhat P G (2011) PG's pensive. Scientific temper in daily life-1 (10-04-2013) available at pgbhat.wordpress.com/2011/06/10/scientific-temper-in-daily-life-1/.

Cobern WW (1994) Worldview theory and conceptual change in science education. Cobern W W, 'Worldview Theory and Conceptual Change in Science Education' (1994) Scientific Literacy and Cultural Studies Project: 1-33.

Danielou A (1987) While the Gods play: Shaiva oracles and predictions on the cycles of history and destiny of mankind, Inner Traditions International, Rochester, Vermont: 45-77.

Dhar P L (2009) Developing scientific temper (10-04-2013) available at pldhar.files.wordpress.com/2009/09/scientific-temper.pdf.

Ehrlich R (2010) Optimizing the Efficacy of Intercessory Prayer: Results from a Quadruply-Blind Study, Webmed Central Clinical Trials 1(9): 1-7.

Fynman R (1966) What is science? (18-06-2014) available at http://www.fotuva.org/feynman/what_is_science.html.

Ghosh P (2013) Exposing baba black sheep, *The Times of India*, 25th August.

Gray R D and Atkinson Q T (2003) Language-tree divergence times support the Anatolian theory of Indo-European origin, *Nature* 426: 435-439.

Hodson D (1985) Philosophy of science, science and science education, *Studies in Science Education* 12: 25-57.

Jahagirdar R A, Collected works of Justice R.A. Jahagirdar: Scientific Temper, Rationalist Foundation: 3-4, 14, 19-20.

Khalick F A, Boujaoude S, Duschl R, Lederman N G, Naaman R M, Hofstein A, Niaz M, Treagust D and Tuan H L (2003) Inquiry in science education: international perspectives, *Science Education* 88(3): 397-419.

Kosambi D D (1964) The culture and civilization of ancient India in historical outline Vikas Publishing, India.

Mahanti S (2013) Perspective on Scientific temper in India, *Journal of Scientific temper* 1(1&2): 46-62.

Mannen M V (1977) Linking ways of knowing with ways of being practical, *Curriculum Inquiry* 6(3): 205-228.

McQuillan R, Eklund N, Pirastu N, Kuningas M, McEvoy B P, *et al.*, (2012) Evidence of inbreeding depression on human height, *PLOS Genetics* 8 (7): 1-14.

Metspalu M, Romero I G, Yunusbayev B, Chaubey G, Mallick C B, *et al.*, (2011) Shared and unique components of human population structure and genome-wide signals of positive selection in south Asia, *American Journal of Human Genetics* 89: 731-744.

Moorjani P, Thangaraj K, Patterson N, Lipson M, Loh P R, *et al.*, (2013) Genetic evidence for recent population mixture in India, *American Journal of Human Genetics* 93: 1-17.

Morton N E, Crow J F and Muller H J (1956) An estimate of the mutational damage in man from data on consanguineous marriages, *PNAS*. 42: 855-863.

Nehru J L (1946) The Discovery of India (3rd ed.) Penguin Books India, New Delhi: 568, reprinted in 2004.

Sen A (2005) The Argumentative Indian, Penguin Books India, New Delhi.

Shukla P (2012) Out of the frying pan into the fire: journey of India's middle class women — a historical perspective, LLILJ 2(2): 1-9.

Sitaraman R (2008) The value of vitalism and Schrodinger's What is Life? In the contemporary classroom, *Biochemistry and Molecular Biology Education* 37 (3): 152-155.

Sitaraman R (2011) The treasure of the humble: lesson from baker's yeast, *Biochemistry and Molecular Biology Education* 39 (4): 261-266.

Sunil (2009) A scientific temper. (10-04-2013) available at balancinglife. blogspot.in/2009/03/scientific-temper.html.

Tayebi N, Yazdani K, and Nagshin N (2010) The prevalence of congenital malformations and its correlation with consanguineous marriages, *Oman Medical Journal* 25 (1): 37-40.

Positive Atheism (2000) Development of philosophical thought and scientific method in ancient India. [online] June 2000. (10-8-2013) available at http://www.positiveatheism.org/india/science.htm.