CHAPTER II

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PROMOTING SCIENTIFIC TEMPER IN EDUCATION BY IGNITING THE MIND: AN OVERVIEW

2.1 Introduction

Education is the foundation for scientific and technological advancements and personnel training of human beings. In the midst of overall anxiety of the modernization drive, education especially Science Education should automatically get a strategic priority. Science education will give the means of applying moral principles more effectively in the service of our fellow beings. True morality lies in the awareness of the spiritual reality and calls for a disciplined life, a clean and useful life dedicated to disinterested service. Such a life is not opposed to science. The Founding Fathers of the Indian Republic have given great importance to the cultivation of “Scientific Temper” among the citizens of this country by suitably incorporating it in our constitution.

Derived from the philosophical writings of John Dewey and the Enlightenment tradition, Scientific Temper implies commitment to the method of science as means of acquiring knowledge, promoting a spirit of critical enquiry and respect for scientific evidence. It is a commitment to the philosophical and worldview components of science. Education promoting Scientific Temper would require training and understanding in all these various aspects of practice of science. It resonates well with the ‘nature of science’ approach to the teaching of science. It can also be the spirit that can possibly reverse the steady downward trend of our world’s health and wealth (Viswanathan, 2011).

2.2 Perspectives Related to Scientific Temper

Science deals with the domain in positive knowledge but the temper, which it should produce, goes beyond that domain. The term, ‘Scientific Temper’ means the attitude of the scientist emphasizing that nothing in the world should be taken for granted or accepted on the basis of blind faith without it being subjected to a test of reason. Scientific Temper thus stresses investigation, seeks proofs without any bias or prejudice. It is a part of affective disposition, an attitude and mental and cultural tradition, which matters concerning the material world, relies on analysis, questioning
and reasoning to arrive at a judgment or conclusion, or thought in relation to matters of everyday material life (Malcom, 1984).

Scientific Temper refers to an open, question seeking mind. A mind that seeks truth and accepts it when proves. A mind that is curious to understand the ‘whys’ and ‘hows’ of life while accepting that all questions may not be fully answerable. The defining characteristics of a scientific mindset are curiosity, logical ability, objectivity, emphasis on empirical evidence, open-mindedness, ability to recognize self-limitation, and an interest in new developments. An individual with good Scientific Temper can understand the phenomena of nature and human behavior, and accordingly behave to prove as an ideal individual in one’s own family as well as in the society in which he lives (Rao, 1996).

Scientific Temper represents spirit of enquiry and as such involves the process of logical reasoning. It tries to find out the cause and the rational justification of an event objectively and is free from all prejudices and makes believe. Scientific Temperament denotes a type of frame or disposition of mind which is free from superstition, prejudices, rigidness, obscurantism, conformity, close mindedness, irrationality, un-innovativeness, subjectivity and other parochial tendencies.

Scientific Temper, Scientific outlook and scientific attitude may be philosophically and pedagogically different from one another but what is of practical importance is the common thread which runs through all three of them that is the method of science. Thus the method of science is central to Scientific Temper (Sehgal, 1993). The most important characteristics associated with Scientific Temper are untiring search for truth, but with an open mind and a spirit of enquiry. “Scientific spirit is essentially one of tolerance, one of humility, one of realization that somebody else also has a bit of the truth” (Nehru, 1946). Scientific Temper is a process of thinking to act objectively, rationally based on available evidences at the time of making decisions (Sood, 2004). It is a value based process to look at events and objects culminating in a world view perspective.

2.2.1 Scientific Temper in the Words of Great Personalities

Scientific Temper is a term supposed to have been first employed several decades ago by Nehru in the context of India’s overall development through
harnessing of science and technology. Since then, this term has been mouthed, spoken of, written and bandied about, without always being understood or comprehended fully. In the modern Indian context the idea of inculcating Scientific Temper has been argued most forcefully by Nehru. Nehru places two major arguments in support of giving such a primordial importance to the task of imparting Scientific Temper in every Indian Citizen. They are:

a) Protection against the superstitious beliefs of the traditional Indian Society.

b) It is only with the changed way of thinking that Indians can imbibe the scientific and technological capabilities essential for building an industrially developed society in India.

Nehru used to say that “Scientific Temper is the search for truth and new knowledge, the refusal to accept anything without testing and trail the capacity to change previous conclusions in the face of new evidence, the reliance on observed fact and not preconceived theory”.

Nehru (1946) described the concept of Scientific Temper as follows:

“A person who cannot understand another’s view point is to that extent limited in mind and culture, because nobody can presume to have the fullest knowledge and wisdom or truth. If we shut our minds to that, then we not only deprive ourselves of it but we cultivate an attitude of mind which is opposed to that of uncultured man. An open mind is scientific in its approach to life’s problems”.

The concept of Scientific Temper is very much exemplified in the following poem by Tagore (1913).

“Where the mind is without fear and head is held high;
Where knowledge is free:
Where the world has not been broken up into Fragments by narrow domestic walls;
Where words come out from the depth of truth:
Where tireless striving stretches its arms towards perfection;
Where the clear stream of reason has not lost its way into the dreary desert sand of dead habit;
Where the mind is led forward by the ever widening thought and action-
Into that heaven of freedom, my father, let my country awake”.

Buddha substantiated the characteristics of Scientific Temper as follows:
“Believe nothing merely because you have been told it; Or because it is traditional Or because you yourself have imagined it; Do not believe what your teacher tells you, merely out of respect for the teacher; But whatever after due examination and analysis, You find to be conducive to be the good, The benefit, the welfare of all beings, That doctrine believes and clings to, and take it as your guide”.

Kalam (2002), Former President of India has recognized the importance of Scientific Temper and stated, “every Indian must develop Scientific Temper, science and spiritualism seek the same divine blessings for doing good for the people….. science tries to provide solutions for a better material life, while spiritualism looks at answer on how to lead a righteous life”.

Alexander (1995), Former Governor of Maharashtra states that,

“Scientific Temper is not something that can be brought about by an expansion in the number of institutions of Science and Technology, but is an attitude of mind characterized by the spirit of inquiry and acceptance of the right to question and to be questioned”.

Honorable Former Prime Minister of India Vajpayee (2003) said,

“There is a need to develop Scientific Temper using Science and Technology, which is the basis of development in modern world. India has secured a place among leading country. People should develop Scientific Temper, which is also the aim of new Science and Technology policy, people should be aware of the Indian Scientific Achievements. It is significant especially because, year 2004 has been declared as the science awareness year”.

Rao (2014), renowned scientist and recipient of the Bharat Ratna, has said that “there is a need to give fillip to science and said that Scientific Temper is
something, we don't have in this country”. He stressed on the need for providing more resources for scientific research”.

2.2.2 The Relevance and Need of Scientific Temper

The original meaning of science is ‘reasoned knowledge. The Scientific Temper represents a spirit of query and as such involves the process of logical reasoning. The features of Scientific Temper are mainly two-fold:

1. Scientific Temper refers to a mentality or an outlook rather than a specialized body of knowledge. It addressed itself to universalist concerns of “values of life” rather than to narrow and specialized questions of scientific research and application.

2. Unlike scientific expertise alone, the project of Scientific Temper was a call for the diffusion of “science mindedness” throughout the population. The growth of Scientific Temper was measured by the extent to which ordinary people were using the methods of science to life’s problems (Roy, 2007).

Clearly what the above meant was that science would not just played a role in building scientific expertise but also help to reject superstition, prejudice and injustice. Yashpal (2005) has noted, “science will also have to come forward in changing our thoughts and eradicating various social evils, including casteism”. India, in Nehru’s vision, could become a great country if the people adopted such a ‘Scientific Temper.’ Nehru pointed to the contradictions in the lives of scientists themselves who uphold science in the laboratories but discard science in everything else they do in their life. With lack of Scientific Temper, ability to take rational decisions weakens. This may be the reason why the concept of “Scientific Temper” was built-in in our constitution (Richa, 2012).

Developing Scientific Temper is one of the fundamental duties of a citizen of the country and is enshrined in the Fundamental Duties Article 51-A(h) of the Constitution of India. But the concept is far from known to the Western world. Article 51 A of the constitution which deals with fundamental duties makes it a duty of every citizen to develop a Scientific Temper.

Article 51 A of the Constitution also makes it a duty of every citizen to develop Humanism and spirit of enquiry and reform. It further makes it the duty of
every citizen to abide by the constitution and respect its ideals and Secularism is one of the most important ideals of our Constitution.

Secularism, Humanism and Spirit of enquiry are directly related to Scientific Temper. Therefore, this is a good reason enough for us to first of all, find out what exactly is Scientific Temper, and then to try and cultivate it. If a person has Scientific Temper, he can understand and solve his problems with much less difficulty or stress, and he would be reasonable in his decisions and creative in his activities (Yadav, 2011).

In the final analysis, to do justice to Nehru’s vision for India, Scientific Temper could be a useful concept in ‘deschooling’ our society from received wisdom about obscurantist and superstitious practices that it is led to believe is in its interest. Scientific temper has to be an essential component of the socialization of our populace and needs to be promoted as an integral approach to nation-building. If that succeeds, then there can be no greater tribute to Nehru and the millions of children who form the destiny of our nation (Guha, 2005).

2.2.3 Igniting Young Minds with Scientific Temper

In our country, where a large section of the society is still caught in the quagmire of superstitions and obscurantist practices, inculcating Scientific Temper among the citizens is of paramount importance for development of the nation. This is best done during the childhood and is therefore essential that the school curriculum should respond adequately to this important need. This demands inculcation of values like spirit of inquiry, courage (to question), objectivity, honesty and truthfulness, which are precursors to the development of various traits characterizing Scientific Temper. The spirit of inquiry, so natural in most children actually gets stifled by the drab teaching-learning environment created by the didactic teaching methodology. Even learning of science, which should be a joy of discovery, becomes a burden—memorizing so many ‘facts’, formulae, chemical reactions etc. It is therefore of paramount importance that education process be made joyful, with the teachers acting as facilitators of learning, as friends and guides. The child must be free to learn, what he chooses to, at the pace that he relishes, and must be free to make mistakes without the fear of being reprimanded by the teacher. There exist numerous success stories of schools where education is imparted by a variety of means like stories, painting,
recitation, games, group projects, self-reading etc. so that the child’s enthusiasm for learning does not diminish. In such schools the children are not afraid of asking questions to their teacher and friends and thus their inquisitiveness is strengthened.

Well-designed curricular activities carried out in the school help the children to integrate the knowledge acquired with practical observations in a scientific framework thus laying the basis for development of a scientific outlook in the children. But these formal experiences need to be reinforced through activities which are essentially informal and out of school. The purpose of these activities is essentially to make the children realize that their real life perceptions and experiences can become the basis of new knowledge if certain systematic approach is adopted in performing these activities. Thus the job of the school and the teacher does not end with organizing relevant experiences within the school but goes beyond to encouraging children to indulge in more free explorations outside the school premises (Govinda, 1992).

An effective method of fostering Scientific Temper is imparting knowledge of science through experimentation and demonstration by involving students directly in activities similar to how scientists operate in discovering new knowledge. This is usually referred to as the discovery approach to teaching and is eminently suited to teaching science. Carin and Sund (1970) give numerous examples of discovery lesson plans for a variety of sciences – physical science, earth science, biological sciences – wherein through simple experiments the students discover for themselves various scientific concepts. To inculcate Scientific Temper among the students, they need to be placed in situations – through role play, quizzes, model making etc. - where critical and rational thinking are needed. It is also necessary to make them aware of the impact of science on society by arranging visits to factories, hospitals, research laboratories, showing suitable video films, organizing talks by eminent scientists and technologists, and encouraging them to participate in science exhibitions. Appropriate educational technologies have the potential to make scientific concepts more accessible through visualization, modeling, and multiple representations. The use of technology in the classroom leads to considerable development of scientific thinking in children.
In science, impossible does not exist. Inventions and discoveries are the products of constant endeavor by creative minds, envisioning ever-new outcomes. With vivid imagination and consistent effort, the forces of the universe can be made to work for an ignited mind (Kalam, 2005). Today’s society needs new generation of creative scientists. For that, an environment for research and challenging mission is essential. Teachers have a greater responsibility in moulding students with scientific mindset. The science teacher should provide opportunities for independent extra reading, laboratory works, improvisation of apparatus, problem solving etc. The increase in the degree of consistency of the environment helps in developing and inculcating Scientific Temper and academic achievement in the pupil.

Vision of the former Indian President, the scientific legend Kalam shared in his book ‘The Ignited Minds’ is,

“Dream, dream, dream.
Dream transforms into thoughts.
Thoughts result in actions” (Kalam, 2002)

Our teachers can contemplate this and devise methods to incorporate Scientific Temper in our young minds which will go a long way in the technological progress of this country. If India were to succeed and fulfill the visions of great citizens of the country, it has to foster Scientific Temper and scientific creativity in the citizens with absolute capacity. It is easy to recognize, that these steps can be easily cultivated in young minds so that they will blossom into worthy citizens of the great country in future.

2.2.4 Scientific Temper and Vedic Science

Science and Religion aptly depend on perceptions about human and their existence. Science is the answer to man’s prayer for better life. Religion gives man a sense of direction and purpose in life. In the Vedas the focal point is that the human being and the knowledge therein is for the welfare of the entire mankind. This knowledge also helps the human being to develop scientific outlook. The Vedic science is only in the context of material and spiritual welfare of human being. Unlike the present day, physical sciences are part of Vedic metaphysics, which unequivocally explain that physical sciences pertain mostly to the external world that is objectively real and not absolutely real.
The unity in diversity is the message of Vedic physical and metaphysical sciences. While matter is the cause of diversity owing to three primordial subtle particles of purity, activity and passivity present in it, the spirit (jiva) provides the necessary unity. Many scientists held that the Sun is moving and the earth is static and vice versa. The gross matter and its atoms are inert as observed by the scientist of classical mechanics and now in the 20th century particle physics have found that atom is no longer inert and matter also experiences “fatigue” and many more contradictions. The Vedic science remained consistent during all this period. However, science is now itself proving in the laboratory some of the Vedic scientific truths.

As regards the creation of earth and life on it the modern scientists are coming to new discoveries that all life came out of inanimate things. The world itself came in to existence owing to Big Bang or intense energy but still would not like to call it Cosmic Energy of the God.

At each stage of education the aim is to create scientific outlook amongst the students so that all superstitions, blind faith and conviction could disappear in society. The Vedas combine science with metaphysics and clearly mention that it is God who is the giver of knowledge of all sciences as “Sahstra sam”. The scientists are advised to study cause and effect of all material elements and also how the objects are produced and there after utilize these properly. By following these guidelines they can alleviate sufferings of the people. Without the knowledge and practical application of physical sciences, it is not possible to eradicate poverty and attain prosperity (R.V. 1-34-1 to 5).

The philosophy of ‘Advait Vedanta’ or absolute monism is more like modern science. The universe is made of one substance i.e., matter whose form is perpetually changing. While the sum total of the entire energy in the Nature remains always the same, explanation of things in the entire substance are to be found within their own nature. No external beings or existence are required to explain what is going on in the universe with its corollary of a self-existence universe. There is something beyond gross atoms but human senses and material instruments have not succeeded in finding these out. Thus there is indirect confirmation of the scientific version of the concept of ‘Vedic Maya’. As brought out earlier the physical sciences in the Vedas are part of
the Design of the God, who is described also as “Vishwa Karma” - the supreme
designer and architect of the universe. All these designs are based on ‘Rta’ that are
permanent truths and are his laws of social, moral and physical order (Prem, 2011).

2.2.5 The Six Pillars of Scientific Temper

Scientific Temperament includes six components such as:

i. Scientific Literacy

ii. Scientific Attitude

iii. Scientific Thinking

iv. Scientific Method

v. Scientific Perception

vi. Scientific Habit

i. Scientific Literacy

Scientific literacy is one of the important aspects of Scientific Temper. To a
large extent it is a matter of feeling and of value. These feelings and values are
expressed by such words as curiosity, accuracy, quality, persistence, wonder, awe and
reverence. These feelings and values however, must be founded on a measure of
knowledge and a desire to increase that measure. Scientific literacy is a broad term
that incorporates scientific ideas and concepts within and across various scientific
disciplines, as well as scientific practices (Yael, 2006).

Scientific Literacy involves the ability to solve daily problems through the
method of science and consequent development of the scientific outlook (Joseph,
1994). Programme for International Student Assessment (PISA) moved to
determining scientific literacy in three dimensions. First, scientific concepts, which
are needed to understand certain phenomena of the natural world and the changes
made to it through human activity. The main content of the assessment is selected
from within three broad areas of application: science in life and health; science of the
earth and the environment and science in technology.
Second, scientific processes, which are centered on the ability to acquire, interpret and act upon evidence. Five such processes that are present in OECD/PISA relate to:

- the recognition of scientific questions
- the identification of evidence
- the drawing of conclusions
- the communication of these conclusions
- the demonstration of understanding of scientific concepts.

Third, scientific situations, selected mainly from people's everyday lives rather than from the practice of science in a school classroom or laboratory, or the work of professional scientists. Bybee (2003) suggested a comprehensive theoretical scale that is more suitable for the assessment of scientific literacy during science studies at school, since its hierarchy can be easily transferred to instructional purposes. This scale was used as one of the theoretical frameworks for the current study. The scale suggests three levels of scientific literacy such as, Cultural or nominal scientific literacy, Functional scientific literacy and Multidimensional scientific literacy.

Based on the level of Scientific Literacy, Norris and Philips (2003) reported that the important components of scientific literacy are:

a. Ability to apply relevant scientific knowledge in life situations.

b. The ability to utilize the process of scientific inquiry.

c. Interest in new developments in society.

d. Ability to think scientifically.

e. Ability to use scientific knowledge in problem solving

Laohaphaibool (1992) argues that science teaching should not only provide pure science concepts, but also consider the relationship between science, technology and society. This way of science teaching could enhance students scientific literacy. To provide science teachers with ideas for teaching for scientific literacy, Laohaphaibool developed the pyramid analog that includes (1) understanding of the
environment, (2) thinking process and reasoning to investigate knowledge about those environment and (3) scientific habits of mind.

**Figure 2.1.** Analogy of scientific literacy

Scientific literacy may provide benefits to individuals in a variety of ways. Durant and Thomas (1992) have given some reasons for developing scientific literacy. They are:

- The scientifically literate person understands the nature of scientific knowledge.
- They accurately apply appropriate science concepts, principles, laws and theories in interacting with the universe.
- Uses processes of science in solving problems, making decisions and understanding of the universe.
- The scientifically literate person interacts with the various aspects of his universe in a way that is consistent with the values that underlie science.

### ii. Scientific Attitude

The term 'attitude' encompasses a wide range of affective behaviors. It is a mental state of readiness exerting direct or indirect influence upon an individual's
response to all objects and situations with which it is related. Scientific attitude according to Gauld and Aukins (2002) is a composite of a number of mental habits or tendencies to react consistently in certain ways to a novel or problematic situation. Rao (1996) stated that the most useful scientific attitudes are open mindedness, critical mindedness, respect for evidence, suspended judgment and intellectual honesty, willingness to change opinion, search for truth, curiosity and rational thinking. It is the most important outcome of science teaching. Scientific Attitude consists of five dimensions namely:

1. Rationality
   a. Commitment of the value of rationality.
   b. Tendency of test traditional beliefs.
   d. Acceptance of criticalness.
   e. Challenge of authority.

2. Curiosity
   a. Desire for understanding new situations that are not explained by the existing body of knowledge.
   b. Seeking to find out the ‘why and how’ of observed phenomena.
   c. Giving emphasis on the question in approach for novel situation.
   d. Desire for completeness of knowledge.

3. Open mindedness
   a. Willingness to revise opinions and conclusions.
   b. Desire for new things and ideas.
   c. Rejection of singular and rigid approach to people, things and ideas.
4. Objectivity of intellectual belief
   a. Demonstration of the greatest possible concern for observing and
      recording facts without any influence of personal pride, bias or
      ambition.
   b. Not allowing any change in interpreting results on the basis of
      present social, economic or political influences.

5. Aversion to superstitious belief.
   a. Rejection of superstitions and false beliefs.
   b. Acceptance of scientific facts and explanation (Billech &
      Zakhariadas, 1975).

iii. Scientific Thinking

Scientific thinking differs from the learning of scientific facts in such a way
instead of learning what other people have discovered. Scientific thinking leads
children to make their own discoveries. Scientific thinking is defined as the
application of the methods or principles of scientific inquiry to reasoning or problem-
solving situations, and involves the skills implicated in generating, testing and
revising theories, and in the case of fully developed skills, to reflect on the process of
knowledge acquisition and change (Wilkening & Sodian, 2005). It is a conjoint
process of analysis, synthesis or discrimination and identification. Scientific thinking
involves characteristics such as,

i. Curiosity
ii. Reasoning
iii. Open-mindedness
iv. Ability to manage the new situations
v. Interest in future (Singh, 1989).

Scientific Thinking is based on three things, using empirical evidence,
practicing logical reasoning and possessing a skeptical attitude about presumed
knowledge that leads to self-questioning, holding tentative conclusions and being
undogmatic. A well cultivated scientific thinker:

- raises vital scientific questions and problems, formulating them clearly and
  precisely;
• gathers and assesses relevant scientific data and information, using abstract ideas to interpret them effectively;
• comes to well-reasoned scientific conclusions and solutions, testing them against relevant criteria and standards;
• thinks open-mindedly within convergent systems of scientific thought, recognizing and assessing scientific assumptions, implications and practical consequences; and
• communicates effectively with others in proposing solutions to complex scientific problems (Richard & Linda, 2008)

Chaille and Britain (2003), in “The Young Children as Scientist”, present a constructivist curriculum model for science and emphasize the importance of scientific thinking. They clearly debunk the notion that the constructivist approach is incompatible with science education. Scientific thinking is, in short, self-directed, self-disciplined, self-monitored and self-corrective.

iv. Scientific Method

Scientific Method is an organized plan used for gathering, organizing and communicating information. It is the method of procedure adopted by scientists in their investigation of natural phenomena, the way in which scientific generalizations are arrived and made use of. In addition, the scientific method uses reasoning to produce useful and reliable models of nature and natural phenomena. Reasoning is a cornerstone of the scientific method because scientists often cannot directly observe a cause and can only observe its consequences (Kim, 2012). The scientific method is a step-by-step approach towards solving a problem. It involves certain principles of reasoning to help organize thoughts and procedures for finding a possible explanation or answer to a question. The scientific method generally involves following six steps,

i. State the problem
ii. Gather information
iii. Form a hypothesis
iv. Test the hypothesis
v. Analyze data
vi. Draw conclusions
The modern educationist, particularly John Dewey advocates Scientific Method and Scientific Attitude as objective of formal education. The Scientific Method which has a reference to a procedure or a mode of investigation by which scientific and systematic knowledge is acquired is based upon certain ‘articles of faith’ as shown below (Singh, 1989).

Figure 2.3. ‘Articles of faith’ for the acquisition of scientific knowledge
Scientific Method involves reflective thinking and reasoning results from the achievement of certain abilities, skills and attitudes. It is a form of critical and reflective thinking and reasoning based on careful measurement and controlled observation. It needs a continuous training with problems concerning the students in an atmosphere of careful and persistent investigation.

v. Scientific Perception

A man of Scientific Perception always tries to reach the cause or the primary source of the event. One does not believe anything without any evidence. Important dimension of Scientific Perception is observing any event, situation, cause, problem, rule and principles as a scientific or critical outlook (Singh, 1989). Critical thinking is that mode of thinking - about any subject, content or problem - in which the thinker improves the quality of his or her thinking by skillfully taking charge of the structures inherent in thinking and imposing intellectual standards upon them (Richard & Linda, 2008).

To tackle the present problems of population boom, health, pollution, environment, water etc the need is the imbibement of Scientific Temper and of a critical outlook towards technology. Ennis (1987) suggests that “Critical thinking is reflective reasoning about beliefs and actions and it is one of the important mental capacities”. Critical thinking helps us to uncover bias and prejudice. It is a path to freedom to thinking and expression. It is the process of examining, analyzing, questioning and challenging situations, issues and information of all kinds (Brookfield, 1987).

![Figure 2.4. Core critical thinking skills](image)
According to Scriven (1996) Critical thinking is the intellectually disciplined process of actively and skillfully conceptualizing, applying, analyzing, synthesizing, and/or evaluating information gathered from or generated by, observation, experience, reflection, reasoning or communication, as a guide to belief and action. Someone with critical thinking skills is able to do the following:

- understand the logical connections between ideas.
- identify, construct and evaluate arguments.
- detect inconsistencies and common mistakes in reasoning.
- solve problems systematically.
- identify the relevance and importance of ideas.
- reflect on the justification of one's own beliefs and values (Joe, 2004).

vi. Scientific Habit

Scientific Habit may be called as the correlate of Scientific Temper. A person having Scientific Habit keeps thinking that every work is governed by scientific laws and there is some reason behind every work. Scientific habits of mind are curiosity and openness to new ideas (Settlage & Southerland, 2007). Thinking based on Scientific Habit is free from conservation, superstition and narrow, rigid, callous outlook.

Superstition in life goes by various names such as rituals, beliefs, customs, and personal values (Srinivasacharyalu, 1992). Superstitions are galore in society and they are born out of fear and anxiety. The Oxford Dictionary describes superstition as ‘a habit or belief based on irrational fear of unknown or mysterious’. Superstition is a belief in supernatural causality: that one event leads to the cause of another without any physical process linking the two events; a false conception of causality that contradicts natural science (e.g. astrology, omens, witchcraft etc). It is a belief, not based on human reason or scientific knowledge, that future events may be influenced by one’s behavior in some magical or mystical way. It is a belief in sign of things to come which is contrasted with fact, reality, science and truth (Desai, 2012). The important areas of scientific habits of mind are:
• Aversion to Superstitious belief
• Curiosity
• Openness to new ideas
• Reasoning ability
• Rationality and
• Mistrust of arguments from authority (Neil, 2008).

The curriculum makers should also take into consideration the superstitious belief that are prevailing in the society and see that proper curricular experiences are provided from pre-primary level to develop negative attitudes towards these superstitious beliefs.

2.2.6 Theories Related to Scientific Temper

Attitude formation occurs through classical conditioning, operant conditioning and modeling (observational learning). Advertising relies to a great extent upon modeling when it shows a famous person using and liking a product. Some theories describing the formation of attitudes follow:

i. Regulative Theory of Temperament

Strelau (1983) postulated a regulative theory of temperament based on Pavlovian concept of types of the central nervous system (CNS), theories of arousal and arousability and a theory of action. Strelau suggests that reactivity and activity are the two basic dimensions responsible for individual differences. Reactivity is a temperament trait that reveals itself in relatively stable and characteristic intensity or magnitude of reactions. It co-determines sensitivity and endurance. Activity is a temperament trait that reveals itself in the amount and range of undertaken actions, i.e., goal-directed behaviors of a given stimulative value. By means of activity the individual regulates the level of arousal in order to attain or maintain the optimal level of arousal.

Strelau states that there is a relationship between reactivity and activity. Reactivity is directly determined by physiological mechanisms, whereas activity is an outcome of the level of reactivity and socialization. Reactivity refers to the manner in
which individuals choose to bond with the environment. It refers to the characteristic mode of reacting to stimuli from the environment - the manner in which operant behaviour is established. Activity, on the other hand, is the thrust of energy that flows from the characteristics of the organism as mediated by reactivity. Activity, to use a metaphor, is like the flow of water from its source. Reactivity acts like the set of dams, locks, or flood plains and refers to operant (goal-directed) behaviour. Strelau suggests that high reactive individuals (high sensitivity and low endurance) show low levels of activity, and low reactive individuals (low sensitivity and high endurance) show high levels of activity.

ii. **Cognitive Dissonance Theory**

The theory of cognitive dissonance in social psychology proposes that people have a motivational drive to reduce dissonance by altering existing cognitions, adding new ones to create a consistent belief system, or alternatively by reducing the importance of any one of the dissonant elements (Festinger, 1957). Cognitive dissonance is the feeling of discomfort when simultaneously holding two or more conflicting cognitions as ideas, beliefs, values or emotional reactions. In a state of dissonance, people may sometimes feel disequilibrium such as frustration, hunger, dread, guilt, anger, embarrassment and anxiety. Festinger (1957) proposed cognitive dissonance theory, which states that a powerful motive to maintain cognitive consistency can give rise to irrational and sometimes maladaptive behavior. Dissonance Theory declares that dissonance is an unpleasant motivating state (a feeling) that encourages attitude change to achieve or restore consonance.

Cognitive dissonance is a motivational state caused by tension among competing goals, concepts, perceptions, beliefs, values, ideas or desires. The tension can vary as a function of the importance of the issue in the person's life, and the degree if inconsistency between competing goals or needs. The tension generates a "drive state" in which the individual feels a need to settle the dissonance. In order to diminish the tension, the person must make the dissonant cognitive elements consistent or compatible, or by attenuating the importance of the dissonant elements.

According to cognitive dissonance theory, there is a tendency for individuals to seek consistency among their cognitions (i.e., beliefs, opinions). When there is an inconsistency between attitudes or behaviors (dissonance), something must change to
eliminate the dissonance. In the case of a discrepancy between attitudes and behavior, it is most likely that the attitude will change to accommodate the behavior (Festinger, & Carlsmith, 1959).

**iii. Functionalist Theory**

Katz (1960) proposed a functionalist theory of attitudes. At the psychological level the reasons for holding or for changing attitudes are found in the functions they perform for the individual, specifically the functions of adjustments, ego defense, value expression, and knowledge. The conditions necessary to arouse or modify an attitude vary according to the motivational basis of the attitude. Ego-defensive attitudes, for example, can be aroused by threats, appeals to hatred and repressed impulses, and authoritarian suggestion, and can be changed by removal of threat, catharsis, and self-insight. Expressive attitudes are aroused by cues associated with the individual's values and by the need to reassert his self-image and can be changed by showing the appropriateness of the new or modified beliefs to the self-concept. Brain washing is primarily directed at the value-expressive function and operates by controlling all environmental supports of old values. Changing attitudes may involve generalisation of change to related areas of belief and feeling. Minimal generalization seems to be the rule among adults; for example, in politics voting for an opposition candidate does not have much effect upon party identification. Katz distinguishes four types of psychological functions that attitudes meet. They are Instrumental, Knowledge, Value-expressive and Ego-defensive.

**iv. Temperament Theory**

Temperament arises from genetic endowment. It influences and is influenced by the experience of each individual and one of its outcomes is the adult personality (Rothbart, 2000).

Temperament has been variously defined as:

a. The stylistic component of behaviour.

b. Individual difference in emotional expression.

c. And the arousal component of behaviour.
Temperament refers to ‘inherited personality traits that appear early in life’. The word Scientific Temper is related to the concept temperament. Temperament refers to the patterns and style of a person’s behavior such as energy, quality and intensity in the expression of emotions, attention, self-regulation and tendencies to approach or withdraw from the unfamiliar, on which appears later and develops with maturation. Maturation and experiences in the environment modify the expression of an individual temperament.

According to Hippocrates the human body consists of four types of humors or fluids such as blood, yellow bile, phlegm and black bile. The predominance of one of these four types of fluids in one’s body gives him unique temperament or characteristics leading to particular type of personality. For example, an excess of bile would cause personality to be chronically angry, hence the word choleric (angry), which literally means bile. Similarly an excess of black bile would cause a person to be chronically sad, hence the term melancholy, which literally means black bile (Aggarwal, 2004).

2.2.7 Scientific Temper and its Related Cognitive and Affective Variables

Education must focus on the quality of teaching and learning. The quality is the concept borrowed from the business sector which is more applicable in educational sector but more complex and interactive. It is difficult to define the term quality with precision, since it combines values, attitudes and achievements which form a part of the most complex areas of study in psychology, such as the cognitive, affective and psychomotor areas. Therefore a change in teaching and learning make a corresponding change in the cognitive and psychomotor variables which in turn changes the quality of the individual which is the outcome of scientific temper. Detail regarding the features that support the categorization of variables under cognitive and affective domain is given in the following table.
### Table 2.1

*Features that Support the Categorization of Variables*

<table>
<thead>
<tr>
<th>No.</th>
<th>Variable</th>
<th>Definition</th>
<th>Proponent</th>
<th>Attribute that support the domain- (Affective/Cognitive Variable)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Scientific Temper</td>
<td>It is known about one’s reaction time, by strength or responses, by quality and intensity of moods, and by all that is subsumed under emotional nature.</td>
<td>Singh, 1989</td>
<td>Affective Variable</td>
</tr>
<tr>
<td></td>
<td>Scientific Temper</td>
<td>Scientific Temper is the attitude of open, rational, questioning, curious mind that enables the individual to have a scientific outlook.</td>
<td>Nayudamma, 1995</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Scientific Temper</td>
<td>Scientific Temper is a unified state of mind, comprising thoughts, action and conduct of an individual in a specific situation. It is a part of affective dispositions and a value based process to look at events and objects stimulating in a world view perspective.</td>
<td>Sood, 2004</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Self Regulation</td>
<td>Self-regulation is an integrated learning process, consisting, the development of a set of constructive behaviors that affect one's learning processes and involves three general aspects of academic learning such as self-regulation of behavior, motivation and cognition.</td>
<td>Zimmerman, 1989</td>
<td>Cognitive Variable</td>
</tr>
<tr>
<td></td>
<td>Self Regulation</td>
<td>Self-regulation refers to learners’ abilities to understand and control their learning environments and constitutes a combination of cognitive strategy use, metacognitive control and motivational beliefs.</td>
<td>Schunk, 1996</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Achievement in Biology</td>
<td>Achievement refers to the standard performance of students in the group under consideration for a test developed to measure curricular outcomes.</td>
<td>Good, 1945</td>
<td>Cognitive Variable</td>
</tr>
<tr>
<td></td>
<td>Achievement in Biology</td>
<td>Achievement is the measure of the effects of learning that occurred under partially known and controlled conditions and the extent of change happened in the learner in</td>
<td>Anastasi, 1968</td>
<td></td>
</tr>
<tr>
<td>4. Scientific Creativity</td>
<td>which to attain needs of the domains.</td>
<td>Achievement is the attainment of goals through the abilities over certain criteria, according to the levels of certain domains.</td>
<td>Covington, 2002</td>
<td></td>
</tr>
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<td>-------------------------</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Creativity is a generalized constellation of intellectual abilities, personality variables and problem solving traits.</td>
<td>The term stands for various aspects of divergent thinking ability in science and involves the interplay of all factors of thinking on the one hand, and factors of seeing problem and evaluation on the other.</td>
<td>Ausubel, 1963</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Creativity as the process of becoming sensitive to problems, deficiencies, gap in knowledge, missing elements, disharmonies and identifying the difficulty, searching for solution or formulating hypotheses about the deficiencies, and finally communicating the result.</td>
<td>Torrance, 1970</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Science Interest is a behavior tendency which is an expression of satisfaction of certain needs innate or acquired in the course of adjustment to the environment.</td>
<td>Interest is close to attitudes. It is a positive feeling attached to the abstract and concrete aspects of scientific activity, which manifest in the form of acceptance for and a satisfaction in all activities.</td>
<td>Bhatacharya, 1972</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Social Sensitivity is the inferences one makes while socializing and the role one plays with in a group.</td>
<td>Social Sensitivity is a part of social intelligence and shares some similar characteristics with it. Taking responsibilities for social problems, being open for new thoughts and enhancing other's mood are the certain features of a socially sensitive people.</td>
<td>Thorndike, 1936</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Social Sensitivity is an empathic ability to correctly understand other's feelings and thoughts and to be acquainted with general knowledge of social norms.</td>
<td>Salovey &amp; Mayer, 1990</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bender, et al, 2012</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
2.3 Scientific Temper as a Determinant to Self-Regulation

Self-regulated learning refers to learners’ abilities to understand and control their learning environments. Self-regulated learning involves a combination of cognitive strategies, metacognitive control and motivational beliefs. Cognitive strategies take the form of simple, problem solving and critical thinking strategies. Metacognitive processing refers to knowledge and control of cognitive skills and usually involves planning, monitoring and evaluating learning. Finally, the motivational component refers to students beliefs in their capacity to learn.

Much of the research studies over the past decade have focused on two broad areas; curriculum change in science education and the use of multiple instructional strategies to improve learning. There is strong consensus among science educators that multiple approaches to learning are necessary to improve overall science achievement (Anderson & Hogan, 2000). These include tested instructional practices, collaborative support involving communities of learners and the use of technology to enrich the learning environment. Effective science instruction must not only increase learning, but also help students develop the metacognitive lifelong learning skills needed to succeed at higher levels of science and to reconstruct their conceptual knowledge and procedural strategies when necessary. In addition, effective instruction should help students and teachers become aware of the beliefs they hold about science that affect their learning, or in the case of teachers, affect their curricular and pedagogical decisions.

Magno (2011) found that there is a positive significant relationship between one of the components of Scientific Temper as scientific thinking and Self-Regulation of undergraduate students. According to social cognitive theory, the Self-regulation process involves scientific thinking to accompany self-regulation for the desired goal (Bandura, 1997). Sternberg and Lubart (1995), reported that the function of self-regulation is to oversee and balance the process of creation and sustain conscious effort in creative activity. On the other hand creativity is also related to scientific thinking.

Based on the review of research studies over the past decades, the investigator decided to select six general areas of instructional strategies for improving science learning. The six instructional areas are (a) inquiry based learning, (b) the role of
collaborative support, (c) strategy instruction to improve problem solving and critical thinking, (d) strategies for helping students construct mental models and to experience conceptual change, (e) the use of technology and (f) the impact of student and teacher beliefs. Each of these six areas has been shown to improve metacognitive awareness and self-regulation. Mary (2012) observed that combining science and reading can help to improve students meta-cognitive skills enhancing their ability to draw inferences and make connections as they engage in scientific investigation and reading of literature.

2.3.1 Focus on Self-regulating Skills among Children

Self-regulation is a child’s ability to control his or her behavior. It develops over time and involves many aspects of social, emotional and cognitive development. Self-regulation can also be thought of as the successful integration of emotion (what a child feels) and cognition (what a child knows or can do) resulting in appropriate behavior. It is a deep internal mechanism that enables children as well as adults to engage in mindful, intentional and thoughtful behaviors. Self-regulation has two sides: first, it involves the ability to control one’s impulses and to stop doing something, if needed—for example; a child can resist his immediate inclination to blurt out the answer when the teacher poses a question to another child. Second, self-regulation involves the capacity to do something (even if one doesn’t want to do it) because it is needed, such as waiting one’s turn or raising one’s hand.

As children develop, their regulatory skills become more sophisticated (Blair & Diamond, 2008). Infants begin to regulate arousal and sensory-motor responses even before birth. An infant may suck the thumb after hearing a loud sound, indicating the way of regulating responses to the environment. By age four, children begin to exhibit more complex forms of self-regulation, such as anticipating appropriate responses and modifying their responses when circumstances are subtly different. For example, clapping is appropriate after someone speaks during sharing time at school, but not while a teacher is giving directions.

Most children begin to use self-regulation skills without prompting or assistance during the stages of development. They develop strategies to manage incoming information, choose appropriate responses, and maintain levels of arousal that allow them to actively participate in learning. When children routinely self-
regulate without adult assistance, they have internalized self-regulation (Bronson, 2000). Vygotsky (1934), described internalization as a process in which children progress from co-regulating behavior with an adult to doing so independently. Thus, to develop self-regulation skills, children need many opportunities to experience and practice with adults and capable peers. Although children come to school with different levels of ability to self-regulate, there are four simple strategies teachers can use to help all children develop this critical ability.

i. Teach self-regulation to all children, not just those thought to have problems.

ii. Create opportunities for children to practice the rules of a certain behavior and to apply those rules in new situations.


iv. Make play and games important parts of the curriculum (Bodrova & Leong, 2007).

2.3.2 Theories of Self-regulated Learning

i. Social Cognitive Self-regulated Learning

Self-regulated learning theory evolved from Bandura’s (1997) social-cognitive learning theory. Social Cognitive Theory (SCT) describes learning in terms of the interrelationship between behavior, environmental factors and personal factors. It also provides the theoretical framework for interactive learning used to develop both Constructivism and Cooperative Learning.

According to Social Cognitive Theory, the learner acquires knowledge as his or her environment converges with personal characteristics and personal experience. New experiences are evaluated vis-a-vis the past; prior experiences help to subsequently guide and inform the learner as to how the present should be investigated. Pintrich (2000) which describes Self-Regulated Learning as “an active, constructive process whereby learners set goals for their learning and then attempt to monitor, regulate and control their cognition, motivation and behavior, guided and constrained by their goals and the contextual features in the environment”. This description parallels what Zimmerman (2000) terms a “Triadic Definition of Self-Regulated Learning” involving the interaction of 1. Personal self-regulation involving the adjustment of cognitive and affective states 2. Behavioural Self-regulation
involving self-observing and strategically adjusting performance and 3. Environmental self-regulation involving the observation and adjustment of environmental conditions. He describes these interactions as occurring within a self-regulatory goal setting, monitoring and evaluation loop, as shown in Figure 2.5, including forethought of task, performance, and self-reflection.

**Figure 2.5. Phases and sub processes of self-regulation**

There are two major classes of forethought phase processes: task analysis and self-motivation. Task analysis involves goal setting and strategic planning. There is considerable evidence of increased academic success by learners who set specific proximal goals for themselves, such as memorizing a word list for a spelling test and by learners who plan to use spelling strategies, such as segmenting words into syllables. Self-motivation stems from students beliefs about learning, such as self-efficacy beliefs about having the personal capability to learn and outcome expectations about personal consequences of learning (Bandura, 1997).

Performance phase processes fall into two major classes: self-control and self-observation. Self-control refers to the deployment of specific methods or strategies that were selected during the forethought phase. Self-observation refers to self-recording personal events or self-experimentation to find out the cause of these events.
There are two major classes of self-reflection phase processes: self-judgment and self-reaction. One form of self-judgment, self-evaluation, refers to comparison of self-observed performances against some standard, such as one's prior performance, another person's performance or an absolute standard of performance. Another form of self-judgment involves causal attribution, which refers to beliefs about the cause of one's errors or successes, such as a score on a mathematics test. One form of self-reaction involves feelings of self-satisfaction and positive affect regarding one's performance. Increase in self-satisfaction enhances motivation, whereas decrease in self-satisfaction undermines further efforts to learn (Schunk, 2001).

During the self-regulation process, the individual learner uses social and other environmental conditions as resources to enhance forethought, performance and self-reflection (Zimmerman, 2000). Mackenzie and Hobfoll (2000) extend this social cognitive view by suggesting “self-in-social-setting” regulation which emphasizes the importance of “communal regulation “in which an individual regulates and monitors his or her cognition and actions within the norms and constraints of his or her social network and also their findings suggest that self-regulation is influenced by a host of instructional and environmental conditions, including the clarity and pace of instruction, the amount of structure provided to learners, the degree of learner autonomy, teacher characteristics and other classroom factors.

ii. Self-Determination Theory (SDT)

Self-Determination Theory is concerned with supporting our natural or intrinsic tendencies to behave in effective and healthy ways. The theory was initially developed by Edward and Richard at the University of Rochester. SDT articulates a meta-theory for framing motivational studies, a formal theory that defines intrinsic and varied extrinsic sources of motivation, and a description of the respective roles of intrinsic and types of extrinsic motivation in cognitive and social development and in individual differences.

Deci and Ryan (2000) developed Organismic Integration Theory (OIT), as a sub-theory of SDT, to explain the different ways in which extrinsically motivated behaviour is regulated.
OIT details the different forms of extrinsic motivation and the contexts in which they come about. It is the context of such motivation that concerns the SDT theory as these contexts affect whether the motivations are internalised and so integrated into the sense of self.

OIT describes four different types of extrinsic motivations that often vary in terms of their relative autonomy:

- **Externally regulated behaviour**: Is the least autonomous, it is performed because of external demand or possible reward. Such actions can be seen to have an externally perceived locus of control (Charms, 1968).

- **Introjected regulation of behaviour**: Describes taking on regulations to behaviour but not fully accepting said regulations as your own. Deci and Ryan (2000) claim such behaviour normally represents regulation by contingent self-esteem, citing ego involvement as a classic form of introjections.

- **Regulation through identification**: Is a more autonomy driven form of extrinsic motivation. It involves consciously valuing a goal or regulation so that said action is accepted as personally important.

- **Integrated Regulation**: Is the most autonomous kind of extrinsic motivation occurring when regulations are fully assimilated with self so they are included in a person's self-evaluations and beliefs on personal needs.

Ryan and Deci define vitality as energy available to the self, either directly or indirectly, from basic psychological needs. This energy allows individuals to act autonomously. Many theorists have posited that self-regulation depletes energy but SDT researchers have proposed and demonstrated that only controlled regulation depletes energy, autonomous regulation can actually be vitalizing.

**iii. Self-perception Theory (SPT)**

Self-perception theory is an account of attitude formation developed by psychologist Bem (1972). It asserts that people develop their attitudes by observing their own behavior and concluding what attitudes must have caused it. The theory is counterintuitive in nature, as the conventional wisdom is that attitudes determine behaviors. Furthermore, the theory suggests that people induce attitudes without
accessing internal cognition and mood states (Haemmerlie, & Montgomery, 1982). The person interprets their own overt behaviors rationally in the same way they attempt to explain others’ behaviors. This assessment helps to know about our self and others. Self perception theory proposes that people infer their attitude on the basis of observing their own behaviors. A usually honest student who does cheat on an exam may infer the attitude from the behavior by thinking, “Being first is more important than honesty to me” or “I believe that the end justifies the means.”

2.4 Scientific Temper: A Stepping Stone to Science Achievement

Scientific Temper is the most important outcome of science teaching. This involves the tendency of an individual who is very much inclined to learn scientific concepts. Science experiences and activities provide students the time to explore and discover conceptual understandings on their own. Science activities are one way of developing students questioning skills, which in turn helps students’ comprehension skills in literacy, as they learn to question the vocabulary and the stories while reading. Similar observation was made by Muhammad (2013) in his study that Attitude to Scientific Inquiry and Classroom Enjoyment and Leisure Interest in Science were significantly correlated with science achievement. It is concluded that Attitude to Scientific Inquiry, Classroom Enjoyment and Leisure Interest in Science is strong independent predictor of science achievement scores.

Cooperative learning groups in the science classroom will promote more active learning while students reading and talking together in flexible heterogeneous groupings, as well as games and technology make learning more lively. Cooperative learning provides self-motivated science experiences which help students build prior knowledge and encounter concrete examples of vocabulary concepts. Such lively activities made a corresponding shift in science teaching from the traditional teacher–centered to learner–centered. This shift mainly focuses on problem solving, constructing and reconstructing idea and also formulating valid generalization. These strategies enhance the achievement and attitude of students in secondary schools towards learning science. In recent research studies it was found that the significance of Scientific Temper in science learning. Surekha and Kavyakishore (2013) examined the influence of scientific attitude on achievement in science and observed that
students who possess high scientific attitude achieve better in science than the students possess low scientific attitude.

Joshua (2004) pointed out that there is a positive relationship between scientific Temper and achievement in science. The findings of the above study revealed that it is necessary for teachers to enhance scientific Temper among students for better science learning. Many different strategies and techniques like Problem solving, Brain storming, Seminar, Inquiry training, concept attainment, inductive training models can be incorporated in the usual method of teaching will help to impart scientific knowledge in a way which promote scientific Temper.

2.4.1 Theories Related to Achievement

i. McClelland’s Motivational Needs Theory

McClelland is chiefly known for his work on achievement motivation. His ideas have since been widely adopted in many organizations, and relate closely to the theory of Herzberg. McClelland is most noted for describing three types of motivational need, which identified in his 1961 book, ‘The Achieving Society’:

- Achievement motivation (n-ach)
- Authority/power motivation (n-pow)
- Affiliation motivation (n-affil)
- The need for achievement (n-ach)

The n-ach person is ‘achievement motivated’ and therefore seeks achievement, attainment of realistic but challenging goals and advancement in the job. There is a strong need for feedback as to achievement and progress and a need for a sense of accomplishment.

- The need for authority and power (n-pow)

The n-pow person is 'authority motivated'. This driver produces a need to be influential, effective and to make an impact. There is a strong need to lead and for their ideas to prevail. There is also motivation and need towards increasing personal status and prestige.
Theoretical Overview

- The need for affiliation (n-affil)

The n-affil person is 'affiliation motivated', and has a need for friendly relationships and is motivated towards interaction with other people. The affiliation driver produces motivation and need to be liked and held in popular regard. These people are team players.

McClelland (1965) said that most people possess and exhibit a combination of the characteristics such as the need for achievement (n-ach), the need for authority and power (n-pow) and the need for affiliation (n-affil). Some people exhibit a strong bias to a particular motivational need and this motivational or needs 'mix' consequently affects their behavior and working or managing style. McClelland suggested that a strong n-affil 'affiliation-motivation' undermines a manager's objectivity, because of their need to be liked, and that this affects a manager's decision-making capability.

ii. Atkinson’s and Feather’s Theory of Achievement Motivation

Atkinson and Feather (1966) theorised that orientation results from two separate motives: to achieve success, and to avoid failure. The motive to achieve success is determined by three things: (1) the need to succeed or need achievement (n-Ach); (2) the person's estimate of the likelihood of success in performing the particular task; and (3) the incentive for success—that is, how much the person wants to succeed in that particular task. The motive to avoid failure is determined by three similar considerations: (1) the need to avoid failure which, like the need to achieve success, varies among individuals; (2) the person's estimate of the likelihood of failure at the particular task; and (3) the incentive value of failure at that task, that is, how unpleasant it would be to fail.

In Atkinson's theory of achievement motivation, it was assumed that the goal of achievement oriented activity is to succeed, to perform well in relation to a standard of excellence or in comparison with others who are competitors (Atkinson 1957). Atkinson pointed out that achievement motivation is a non-conscious concern for achieving excellence through individual efforts. Such individuals set challenging goals for themselves, assume personal responsibility for goal accomplishment, are highly persistent in the pursuit of these goals, take calculated risks to achieve the
goals and actively collect and use information for purposes of feedback. Both McClelland and Atkinson’s achievement and motivation theory was based on a personality characteristic that manifested as a dispositional need to improve and perform well according to a certain standard of excellence.

iii. Maslow’s Hierarchy of Needs Motivational Model

Maslow developed the Hierarchy of Needs model in 1940-50 and the Hierarchy of Needs theory remains valid today for understanding human motivation, management training, and personal development.

Maslow posited a hierarchy of human needs based on two groupings: deficiency needs and growth needs. Out of these the first four needs, Maslow identified as deficit needs: i.e., if the needs are not met, they make us uncomfortable and we are motivated or driven by these needs in as much as we are able to sufficiently fulfill these needs. Within the deficiency needs, each lower need must be met before moving to the next higher level. The last four needs, he identifies as growth needs: i.e., we never get enough of these. We are constantly motivated by these needs as they pertain to our growth and development. Maslow’s Hierarchy of Needs Pyramid is given below.

![Maslow's Hierarchy of Needs Pyramid](image)

*Figure 2.6. Maslow’s hierarchy of needs pyramid.*

Being aware of Maslow’s Hierarchy is in the best interests of both the teacher and the students. A teacher should use knowledge of the hierarchy to structure both the lesson plan and the classroom environment; ideally, the classroom would
meet as many of the needs of students as possible, especially the safety, belonging and esteem needs. This of course assumes the physiological needs of the student have been met beforehand. However, if the psychological needs have not been met then the teacher has a basis to understand that the student would not be able to focus on learning (Maslow, 1954). And also cultivate an atmosphere of innovation and self-reflection in class. Maslow’s theory is very brain based and if teachers can apply it in the classroom, the students will feel complete and have a better shot at excelling.

iv. Achievement Goal Theory

The most recent embodiment of the motives-as-goals tradition is achievement goal theory. The basic contention of achievement goal theory is that depending on their subjective purposes, achievement goals differentially influence school achievement via variations in the quality of cognitive self-regulation processes. In effect, then one’s achievement goals are thought to influence the quality, timing, and appropriateness of cognitive strategies that, in turn, control the quality of one’s accomplishments.

2.5 Role of Scientific Temper in Education- Fostering Creative Mind

Science is the product of creative thinking. The development of creative genius among youth should be of prime importance in the education system. It is therefore, a great responsibility to foster this ability to the maximum of the individual’s potential. In the era of scientific information and technology, the development of Scientific Temper, values and scientific creativity is an important task and these are the important outcomes of science teaching-learning. Research in science education should urgently address to the problem of developing Scientific Temper and scientific creativity.

Rishu and Markandey (2011) tried to investigate relationship between Scientific Temper and Scientific Creativity of Senior Secondary Science Students. The observed correlation between components like free from superstitions and scientific creativity, reasoning and logical ability and scientific creativity and cause finding ability and scientific creativity of senior secondary science students is found significant. Three dimensions of Scientific Temper i.e., reasoning, logical ability and cause finding ability shows upward slope with increment in scientific creativity.
Dimensions of Scientific Temper could be predicted on the basis of scientific creativity as a predictor. It is essential to foster, through teaching and learning process, general information regarding science like daily life scientific observations, scientific vocabulary as well as scientific concepts and also reasoning and logical thinking, cause finding abilities of students regarding daily observing scientific effects and its application enhances scientific creativity. Apart from regular curricular activities, teaching–learning activities include various co-curricular activities such as organization of science fair, science exhibitions, scientific debates, scientific quiz and science club, emphasis on numerical based problems, activity based self-learning, and use of ICT etc., will help to foster Scientific Temper and scientific creativity among students.

2.5.1 Characteristics Associated with Scientific Creativity

Psychologists have found out special characteristics of creative scientists for the purpose of selecting scientists for organizations and institutions concerning with scientific developments and creations. The traits are divided into lists of cognitive, personality and demographic characteristics, but the distinction between these are not always ironclad.

- **Cognitive characteristics**

  Certain Cognitive characteristics of scientific creativity are Metaphorical Thinking, Flexibility and skill in decision making, Independence in judgment, coping well with novelty and Logical thinking skills.

- **Personality characteristics**

  Eiduson (1962) reported the following differentiating personality correlates of the creative scientists as highly intelligent, independent of emotional behavior, sensitive to himself and others, original, receptive about his internal needs and wishes, ability to express his experience, more ego involvement in his work.

  Cattell and Drevdhal (1955) found a creative scientist of eminence have high ego strength, intelligence, dominance and low extraversion. With regard to their interests and values. Mackinnon (1963) finds that original and creative persons are less interested in small details. In fact they are more concerned with their meanings
and implications. Creative persons were found to be having both theoretical and aesthetic values.

- **Demographic characteristics**

Certain demographic traits are subject of study, gender and environment (Helson, 1983).

### 2.5.2 Theories of Creativity

Innumerable questions related to creativity, such as the nature of creativity, creative functioning, creative behaviour and the process of creativity owe their answers to the different theories of creativity. While some of these theories are based on simple assumptions, some other has undergone empirical validations.

**i. Divine Inspiration or God-given Gift Theory**

According to this ancient theory, creativity is a gift from God to the human beings and is not universally distributed. The extent to which an individual is endowed with this divine power determines the creativity of the individual.

**ii. Theory of Creativity Equivalent to Insanity**

The states of mind of highly creative persons are somewhat similar to and their behaviour may be quite abnormal and even insane. Yet these findings are not based on objective and empirical studies. The creative person may be far from normal because of his creative pursuits, but his creative strivings cannot be taken as signs of madness.

**iii. Theory of Creativity as Native or Inborn**

Based on this viewpoint, creativity is considered as an innate or inborn trait, a special mental power or unique cognitive ability that cannot be acquired by learning or training. Thus creative persons are born not made.

**iv. Theory of Environmentally Acquired Creativity**

A positive situation or environment that is free and democratic may be said to contribute favourably to the development of creative potential. On the other hand, a closed or inhibited situation or culture may have a detrimental effect on the development of initiative within the individual.
v. **Hemisphere Theory of Creativity**

With relevance to this theory, creative acts are the result of the intervention between the two hemispheres of the human brain. The researches in the field of hemispheric functioning have shown that creative individuals are usually right hemisphere-dominant, while logical, rational thinkers are left hemisphere-dominant.

In addition to the theories discussed above, there are some personality theories which have attempted to explain creative behaviour. They are broadly grouped into four:

i. Psychoanalytic

ii. Humanistic

iii. Behaviouristic

iv. Cognitive

vi. **Guilford’s Cognitive Theory of Creativity**

The cognitive psychologist believes that an individual’s behavior is always based on cognition, the act of knowing about the situation in which behavior occurs. Guilford (1959) discusses the concept of creativity as a cognitive ability, multivariate in nature. In his article “Trait of Creativity”, Guilford stresses the importance of traits, which according to him are properties of individuals. He differentiates between aptitude and non-aptitude traits. Among these fluency, flexibility, originality, elaboration and redefinition are aptitude traits.

The intellectual factors were analyzed by Guilford on the basis of the material involved and in terms of the actions performed. They are as follows:

i. Grouping based on the kind of material involved:

   Depending upon the kind of material involved in the activity, intellectual factors can be arranged in to three parallel groups.

   a. The ability to see relationships between perceived figures.

   b. The ability to deal with relationships between meanings of concepts.

   c. The ability to deal with relationships between letters, numbers or other symbols.
ii. Grouping based on actions performed;

Based on the actions performed, a total creative act involves three aspects. i. Cognition factors (one becomes aware of things which come across) ii. Production factors (one produces something of himself based on that awareness) and iii. Evaluation factors (one evaluates his products of thought). Guilford further subdivided the productive thinking factors into two. i. The convergent type, where thinking converges towards one right answer and ii. The Divergent type, where thinking goes on in different directions.

Guilford hypothesizes that the three components factors of divergent thinking ability viz, fluency, flexibility, originality would influence the whole of creative thinking ability.

- **Guilford’s Multivariate View of Creativity Derived from SI Model**

Guilford considered all the known factors that could be grouped in the intellectual category and proposed a system of those factors which he called the “Structure of Intellect” (Guilford, 1959).

Creativity represents patterns of primary abilities, patterns which can vary with different spheres of creative abilities. Guilford does not accept the concept of a unitary general intellectual ability or of primary mental abilities. In his model of the “structure of intellect” there are five operations. Four types of contents and six products; therefore, there are $5 \times 4 \times 6 = 120$ abilities. On the basis of this, Gilford suggests that there can be 120 ways of being talented on the basis of 120 hypothesized factors. A brief overview of the operations contents and products follows:

Guilford believed that factors contributing to creativity are related, particularly to the 'operational aspect' of intellect; viz. ‘divergent production’ categories. Initially he relates divergent thinking to certain well known ability factors (viz. fluency, flexibility, originality, and elaboration) which seem to go with creative output. Later on, he believed that redefinition abilities, which are 'convergent production' category and sensitivity to problems which falls in the evaluation category of his 'structure of intellect', are also important for creative activity.
2.6 Scientific Temper Based Education: A Pathway to Science Interest

Science unlike other subjects is based on truths and facts. It is a process where experiments are conducted to explain and predict various phenomena. To make Science interesting and create the right ambience and arouse the interest of students, what is needed is to take the process of teaching from dull theoretical and classroom attendance to an interesting and practical level. Mizrap (2010) evaluates the effectiveness of a science method course in promoting interest in science learning and interest in teaching science. Study suggests that a science method course should provide a playful and risk-free learning environment in which science teachers should have the freedom to explore their “wonderings,” curiosity, and questions and inquiry methods that can increase interest in learning science among students. Dewey conceptualized the science interest acquisition process into three distinct and cohesive components: active, based on objects, and having personal meaning or emotional value.

Play and science are often thought of as dichotomous constructs, with play representing fancifulness and frivolity and science representing serious logical thinking. However, the intricate relationships among play, science, and creativity are well established. Classroom atmosphere should be positive, friendly, and supportive, creating a learning environment where participants should be able to engage actively with scientific phenomena and discuss their understandings with friends and instructors. In an activity based approach, teachers often structure learning so that students work in cooperative learning groups (Gurganus & Schimitt., 1995). The use of such groups can encourage the establishment of scientific classroom communities where students work in groups to communicate about and experiment with solutions to scientific problems. Cooperatively structured learning let students formulate and pose questions, share ideas, clarify thoughts, experiment, brainstorm, and present solutions with their classmates. Students can see multiple perspectives and solutions to scientific problems. This leads to the development of science interest. Research on playfulness, science, and creativity suggests that there is a connection between having positive background experiences with science and the development of interest in science. Keeping students engaged and interested in the classroom is an essential factor in successful teaching and learning. To educators, the approach seems obvious:
get students interested and they are more likely to engage in classroom activities. In the end, teaching them becomes much easier.

### 2.6.1 Prediction of Attitude and Interest of Science Students on Achievement in Basic Science

On attitude, Ary et al., (1972) claimed that Attitude is the sum total of a person’s inclination toward a certain type object, institution or idea, while Gronlunds (1976) provided the widest meaning of attitude as that which embraces all aspects of personality development such as individual interest, motives, values, vocational adjustment derived from vocational pursuits and other phases of one’s daily lives. The significance of student’s attitudinal variables as achievement predictors have been emphasized by many researchers who indicated that student’s attitudes and interests could play a substantial role for developing achievement. Ormerod and Duckworth (1975) supported this view by their suggestion that the attitudes of students are likely to play a significant part in any satisfactory explanation of variable levels of achievement shown by students in their school science subjects.

Interest is a motivational construct involving concern or curiosity that promotes attention and concentration toward the object of interest. Student’s interest in science involves three dimensions such as a) interest in a particular context in studying science; b) interest in a particular content connected with that context; and c) interest in a particular activity a student is engaged in, in conjunction with that content (Haussler & Hoffmann, 2000). Therefore, the context in which science is studied is a powerful predictor of student’s interest. Contexts that stimulate interest involve science as a) a means to promote practical competence; b) a socio-economic enterprise; c) a vehicle to enhance emotional experience; d) an intellectually challenging endeavor; and e) a vehicle to qualify for professional life. The level of a person’s interest in science has repeatedly been found to be a powerful influence on learning. Specifically, interest has been found to influence: Attention, goals and levels of learning.

Research in the field of student’s interests and attitudes towards science indicates that these factors affect students’ academic achievement (Haussler & Hoffmann, 2000). Science curricula, school textbooks, teachers and their teaching practices are crucial factors considered to negatively affect students’ attitude and
interest towards science, since they tend to emphasize its academic, strongly intellectual and abstract character, and to present it in a decontextualized way, distanced from everyday life (Semela, 2010).

At school, science teachers play an especially crucial role in the formation and reorganization of student’s conceptions and attitudes towards science and scientists. In particular, teacher’s conceptions and attitudes towards science and scientists establish a hidden curriculum and determine to a large extent their teaching practices. Teacher’s in-adequate understanding of the nature of science may pose difficulties in introducing coherent and compelling teaching practices addressing their student’s interests and experiences and perpetuate to implement traditional, teacher-centered instruction. Hence, the teacher’s views and attitudes towards science have an impact on the respective views and attitudes of their students.

2.6.2 Theories of Science Interest

i. Motivation Theories Views on Interest

Psychologists Deci and Ryan developed a theory of motivation which suggests that people tend to be driven by a need to grow and gain fulfillment. The first assumption of self-determination theory is that people are activity directed toward growth. Gaining mastery over challenges and taking in new experiences are essential for developing a cohesive sense of self. A form of interest is explained differently depended on its back ground motivation theory such as extrinsic motivation theories and intrinsic motivation theories. To extrinsic motivation theorists, especially reinforcement theorists, interest is from one’s need or wants. A child has been reinforced for a certain behavior and his interest is in rewards. Extrinsic motivation as a form of interest sometimes makes kids learn science.

To intrinsic motivation theories, interest has been considered to be an implicit aspect of intrinsic motivation. The most common definition of intrinsic motivation involves performing an activity for its own sake rather than as a means to an end (Hidi, 2000). Self-determination theory focuses primarily on internal sources of motivation such’ as a need to gain knowledge or independence (known as intrinsic motivation). Humans are naturally disposed to seek opportunities to develop competencies. Mastering tasks and developing competencies are intrinsically pleasurable (Stipek,
Intrinsically motivated behaviors are those the person undertakes out of interest, and in this sense interest and intrinsic motivation are used virtually synonymously (Tobias, 1994). In this theory, “interest is conceptualized as the core affect of the self-affect that relates one’s self to activities that provide the type of novelty, challenge, or aesthetic appeal that one desires at that time”.

There are some similarities and differences between intrinsic motivation theories’ view and Dewey’s view of interest. Commonly, interest can be characterized by absorption in the activity. In addition, a state of the loss of self-consciousness in “flow” can mean “unified activity” of self and objects in Dewey’s view of interest. The difference seems to lie in “intellectual” property of interest. However, Dewey differentiates interest in the constructive work from the distinctively intellectual interest in the work. The former interest develops the latter interest. Therefore, Dewey might accept the interest as a form of intrinsic motivation but also claim the importance of the intellectual part of interest as well as the emotional part of it.

ii. Interest Theories Views

From 1980s, some researchers divided interest into two sub-interests and have analyzed properties of each sub-interest. There are two types of interest theories. For the first time, Kintsch (1980) described two forms of interest that occur during reading, emotional and cognitive interest. Emotional interest is the affective response that readers have in the text such as when they are particularly moved by characters’ actions. Cognitive interest results when the text captures the reader’s mind and thoughts, such as when the reader finds an author’s idea interesting. Emotional interest is provoked by situational interestingness and cognitive interest is determined by prior knowledge and the amount of uncertainty in the text (Harp, & Mayer, 1997). Todt and Schreiber (1998) defined interest as follows:

Interests are domain-specific behavior—and experience activating and controlling motives, which are generalized, serving as structures of orientation and appearing in a specific manner as preferences for activities. Interests are essential elements of the structure of self-concept and are fully integrated in the individual’s self-concept.
2.7 Social Sensitivity: The Result of Scientific Temper

In teaching science, it is more important to help students to understand the scientific approach to life and develop a Scientific Temper than it is to impart scientific knowledge or train them in specific scientific techniques. 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 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. "To develop scientific temper" is one of the fundamental duties of the Indian citizens, according to the Constitution of India (Basu, 1993).

Scientific Temper implies thinking, behaving and making decisions on the basis of relevant objective information and logic. Elements of fairness, equality and democracy are built into it (Balasubramanian, 2005). It also means a more positive outlook whereby an individual or community consciously shapes one’s destiny by asking relevant questions and making suitably designed efforts (Rakesh, 2003).

The attributes of Scientific Temper like, honesty, truthfulness, humility, perseverance, positive approach to failure, are essentially some of universal human values which are as important for happiness of an individual as also the society. These various factors are responsible for the development of social values and which leads to social sensitivity. Inculcation of universal human values should become an integral part of the education process. An empathetic feeling towards fellowman, a feeling of oneness among all being, awareness of needs and problems of others and willingness for social service are some of the characteristic features of social sensitivity. “The understanding of the social phenomena and human behavior, knowledge about the social process and its determinants, are essential for designing policies to promote social change and to produce a dynamic society capable of absorbing and utilizing the scientific and technological developments for the welfare of human beings” (Rao, 1985). Social phenomena do not easily lend to experimentation or verification. Thus, if Scientific Temper were to be diffused to ‘solve mundane problems’ of ordinary citizens, the methods of science would have to be enlarged and re-defined in inter-disciplinary perspectives.
Education in the context of social change is not only to impart information and to teach skills to the educand but also to inculcate the values of humanism, democracy, socialism, secularism, peace and national integration. This is necessary for the realization of our democratic and just social order based on equality, social justice, fraternity and freedom. These values will develop an attitude of social sensitivity among people, especially among children and youth. Here are some strategies for developing social sensitivity through science teaching.

- Increase the sensitivity to social justice and harmony.
- Consider the needs of individuals and groups
- Educate oneself on social issues
- Commit to a social awareness plan.
- Ask others to support your efforts to become more socially aware

2.7.1 Theories of Social Sensitivity

i  Kegan’s Constructive Developmental Theory

Kegan’s theoretical perspective has proved to be especially useful when applied to the character development needed by leaders called Constructive Development Theory. It is a model of adult development based on the idea that human beings naturally progress over a lifetime through as many as five distinct stages (Kegan, 1994). It describes a specific way of making sense of the environment, including relationship and responsibilities. Kegan’s theory describes five developmental stages or orders of consciousness:

The Impulsive Mind (1st order of consciousness): The first stage is what mainly characterizes the behavior of children, who are unable to distinguish objects from people in the environment. This is the basic level of development. The person and the environment are linked.

Instrumental Mind (2nd order of consciousness): Individuals in this stage (usually until adolescence) are self-centered and see others as facilitators or obstacles to the realization of their own desires. At this stage, the human being has only one perspective, his own.
The Socialized Mind (3rd order of consciousness): At this level of consciousness, the person identity is tied to living in relationship with others in roles determined by his local culture. Such a person is subject to the opinions of others and is therefore strongly influenced by what he believes others want to hear. Such a stance tends to be reliant on authority for direction and less likely to question, making one a loyal follower. Approximately 58% of the adult population is until this level of consciousness.

The Self-Authoring Mind (4th order of consciousness): The person becomes able to take a step back from its environment and hold it as object, regarding his culture critically. The Self-Authoring mind is able to distinguish the opinions of others from one’s own opinions to formulate one’s own “seat of judgment”. The result is a “self-authoring” of one’s own identity that is independent from one’s environment. Guided by their own internal compass, such a person then becomes subject to his own ideology. These individuals tend to be self-directed, independent thinkers.

The Self-Transforming Mind (5th order of consciousness): It is the highest level of consciousness in Kegan’s model. From this point of view, one is able to regard multiple ideologies simultaneously and compare them, being wary of any single one. This multi-frame perspective is able to hold the contradictions between competing belief systems and is therefore, subject to the dialectic between systems of thought.

Kegan suggests that the Socialized Mind takes as object one’s own needs, interests and desires. Meanwhile it is subject to its social environment, that is, how one is socialized. At this level of consciousness, one’s identity is tied to living in relationship with others in roles determined by one’s local culture. Such a person is subject to the opinions of others and is therefore strongly influenced by what she or he believes others want to hear. It may well include the results of highly invested attention to imagined subtexts that may have more impact on the receiver than the intended message.

ii. Social Ecological Systems Theory

Social ecological systems theory emphasizes interconnections among different elements of a child’s environment, including both proximal influences, such as parents, which affect a child directly, and distal influences, such as the community,
which affect a child indirectly through their impact on more proximal influences. While social ecological models of development are challenging to research because of the large number of interacting elements, they hold great promise because they more accurately represent the complex interchange between children and their environments over time. As with family systems theory, when one part of the environment changes, other aspects of the environment must change to accommodate and maintain homeostasis. Generally speaking, social ecological models of development focus on an individual child at the center of a complex array of influences. Most developmental researchers acknowledge the incredible array of factors that influence children, but few researchers try to incorporate this array into their research designs. For this reason, much developmental research is somewhat limited in its applicability to the everyday lives of children. Social ecological systems theory developed as a reaction to this limited applicability (Schaeffer, 2009).

2.8 Conclusion

Scientific Temper is a mental and cultural tradition that help to understand the why’s and how’s of life. It preserves the traditional beliefs and without hampering man’s curiosity about nature, the wonders of creation and origin of universe. Scientific Temper is necessary for an individual to lead a smooth and comfortable life in the society. In order to enhance Scientific Temper among students specific and clear goal oriented curriculum is essential. Maturation and experiences in the environment modify the expression of individual temperament. An interaction of cognitive and affective states of an individual is detrimental for creative performance. Hence a teaching learning package with varieties of strategies and methods is the only way to ignite the individuals mind by enhancing Scientific Temper and Achievement.