Science education occupies a very eminent place in curriculum both at school and university stages of education in India. Science education is supposed to perform a two-fold task. The prime objective, in individualistic perspective, is the cultivation of a scientific temper and creativity, which includes a spirit of enquiry, a disposition to reason logically and dispassionately, a habit of judging beliefs and opinions on available evidence, readiness to reject unfounded theories and principles, the courage to admit facts, how so ever, unsettling or disagreeable they might be, and, finally, recognizing the limits of reasoning power itself. It is also expected of science education that it would give individuals a firm grasp of the concepts and processes of science and impart to them the ability to use the scientific method of problem solving and the techniques of observation and experimentation in handling problem of comprehension or life.

Research in science education should be urgently addressed to the problem of developing a scientific temper and scientific creativity. Intensive studies will have to be directed towards this fundamental aspect of science education. What does the scientific temper and scientific creativity consist of, precisely? How can they be assessed accurately? Which strategies are most appropriate to inculcate the spirit of science in students? What steps should be taken to ensure that the attitude of scientific enquiry is applied also to extra-scientific domains, including questions having socio-psychological importance?
Research in science education awaits answers to these questions.

**Importance of the study**

In the era of this scientific knowledge, science education has no longer confined to a few seriously devoted persons. Since life in the present world invariably warrants, to variable degrees, knowledge of scientific facts and laws, science has now become a necessary for everyone. Teaching of science for everybody has become an unavoidable part of general education. Nobody can raise question on its inclusion as a subject in the school curriculum. It is included in the school curriculum for the same reasons as any other subject, but in addition science inculcates certain special values peculiar to it and which no other subject can provide. But besides satisfying the usual needs for its inclusion as a subject in the curriculum such as intellectual, cultural, moral, aesthetic, disciplinary, utilitarian as well as vocational values-science learning provides training in scientific method and also helps to develop scientific temper, scientific aptitude & scientific creativity among the learners. These qualities imbibed by the learner through learning science are of great value to a citizen living in the present society of science.

Great minds that our teachers are, they can contemplate this and devise methods to incorporate scientific temper and creativity 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 our great citizens of this country, we have to foster scientific temper and scientific creativity in our citizens with absolute capacity. It is easy to recognize,
that these steps can be easily cultivated in our young minds so that they will blossom into worthy citizens of this great country in future.

**Rationale of the Study**

Creative students and particularly, creative science students have always been a subject of curiosity for researchers. However, only a few studies have been made, those too quite lately, only after 1979, a good quantum of work on creative children’s thinking, learning and working patterns are found. Some researcher investigated personality variables, personality correlates, personality traits and creativity. Many researchers also investigated scientific attitude, scientific aptitude, scientific interest and scientific creativity. But researcher did not found so many studies on scientific temper and its dimensions. Only one study on construction of scientific temper scale by Dubey K.K. (1992) was found.

In the era of scientific information & technology, the development of scientific temper, values & scientific creativity is an important task & these are the important outcomes of science teaching-learning. The review has indicated clearly that scientific temper & scientific creativity are needs of the hour. Researcher did not found any research, in India or even aboard, in which science education outcomes, the scientific temper & scientific creativity are taken together. Thus, there is a gap of knowledge in this field of science. That is why the researcher has undertaken the present study to investigate the scientific temper in relation to scientific creativity of senior secondary science students.
Statement of the problem

“An Investigation into the Scientific Temper in Relation to Scientific Creativity of Senior Secondary Science Students.”

Objectives of the study

Conceptual Objective

To construct a scale for measuring scientific temper of senior secondary science students.

Operational Objectives

1. To compare scientific temper of senior secondary science students in terms of group, sex and locality.
2. To compare scientific creativity of senior secondary science students in terms of group, sex and locality.
3. To compare scientific temper of high and low scientific creative senior secondary science students.
4. (a) To find correlation between scientific temper and scientific creativity of senior secondary science students.
    (b) To find the predicted value of scientific temper on the bases of scientific creativity as a predictor.

Hypothesis

1. There is no significant difference between scientific temper of senior secondary science students in terms of group, sex and locality.
   (a) There is no significant difference between scientific temper of PCM and PCB group of senior secondary science students.
(b) There is no significant difference between scientific temper of senior secondary boy & girl science students.

(c) There is no significant difference between scientific temper of senior secondary urban & rural science students.

2. There is no significant difference between scientific creativity of senior secondary science students in terms of group, sex and locality.
   (a) There is no significant difference between scientific creativity of PCM and PCB group of senior secondary science students.
   (b) There is no significant difference between scientific creativity of senior secondary boy & girl science students.
   (c) There is no significant difference between scientific creativity of senior secondary urban and rural science students.

3. There is no significant difference between scientific temper of high and low scientific creative senior secondary science students.

4. (a) There is no significant relationship between scientific temper and scientific creativity of senior secondary science students.
   (b) The value of scientific temper could be predicted on behalf of scientific creativity.

Definition of Terminology

Scientific Creativity – Scientific creativity is the creativity in the specific field i.e. science. It is the process of formulating hypothesis in scientific situation, testing and retesting these hypotheses and modifying and retesting again and so on. A creative work in science requires
experimentation, intuition, hardworking, insight and continuous involvement in thinking and rethinking.

Creative activity of man consists of fluent production of items of information from memory, flexibility in utilizing them, elaboration upon what is given, and some novel, original transformation of the information matrix. Thus scientific creativity is a multidimensional attribute differentially distributed among people and includes chiefly the factors of fluency, flexibility, originality & elaboration.

**Scientific Temper** – scientific temper is a personality dimension of a person associated with his/her basic derives to think or work in a systematic and scientific way.

**PCM and PCB Group** - PCM, also known as non-medical group, consists of Physics, Chemistry and Mathematics as the optional subjects. PCB, also known as medical group, consists of Physics, Chemistry and Biology as the optional subjects.

**Delimitations**
The following are the delimitation of the present study –

1. The study is limited only to the senior secondary science students belonging to three divisions of Rajasthan State – Jaipur, Ajmer & Bikaner.
2. The study is limited to science students of PCM (Physics, Chemistry & Mathematics) & PCB (Physics, Chemistry & Biology) groups only.
3. The study is limited to only urban & rural senior secondary science students.
4. The construction and standardisation of scientific temper scale is delimited to senior secondary science students in the age group 15-20 years in three divisions – Jaipur, Ajmer & Bikaner of Rajasthan state.

5. The sample of the study is 600 subjects both boys and girls students only.

Second Chapter
Review of the Related Literature

In the present study, 66 related research studies have been reviewed out of which 43 and 23 researches are done in Indian and foreign context respectively.

Third Chapter
Research Method and Procedure

Research Method

Researcher chooses the survey method of research for the present study.

Population

All senior secondary science students of three divisions of the Rajasthan i.e. Ajmer, Jaipur and Bikaner are treated as the population for the present study.

Sampling Method & Sample

Purposive and strata random sampling method is used to collect sample from the population. Equal number of samples is collected from both rural and urban area of the three divisions of Rajasthan- Ajmer, Jaipur and Bikaner i.e. 300 each from rural and urban area. Out of these,
300 samples for each stratum, boys & girls and PCM & PCB group students have been selected.

**Research Tools**

Following two research tools have been used in the study-

1. Verbal Scientific Creativity Test (VSCT) constructed by Dr. V.P. Verma & Dr. J.P. Shukla (2006) is used to measure scientific creativity, having reliability 0.73 and validity range 0.94 to 0.98.

2. Self made scientific temper test is used to measure scientific temper, having reliability 0.68 and validity range 0.68 to 0.72.

**Statistical Treatment**

Formulas of percentile, mean, standard deviation, t-test, product moment correlation and regression analysis are used as the statistical treatment to obtain objectives and verifying hypothesis of the study.

**Fourth Chapter**

**Tabulation and Data Analysis**

Raw data of the study are tabulated and analysed according objective and hypothesis of the study.

**Fifth Chapter**

**Findings**

The following results are found –

**Hypothesis -1**

The hypothesis that there is no significant difference between scientific temper of senior secondary science students in terms of group, sex and locality is tested by calculating C.R. value for PCM and PCB
Research Summary

groups, Boy and Girl & Rural and Urban senior secondary science students. The following results are found:

(i) The observed mean difference between scientific information, free from superstitions and curiosity of students of PCM & PCB group is not found significant. Thus, the hypothesis is accepted.

(ii) The observed mean difference between problem solving ability, reasoning and logical ability, cause finding ability and scientific temper of students of PCM and PCB group is found significant. Thus, the hypothesis is rejected.

(iii) The observed mean difference between scientific information, curiosity and cause finding ability of senior secondary boy and girl science students is found significant. Thus, the hypothesis is rejected.

(iv) The observed mean difference between free from superstition, reasoning and logical ability, problem solving ability and scientific temper of senior secondary boy and girl science students are not found significant. Thus, the hypothesis is accepted.

(v) The observed mean difference between scientific information of senior secondary urban and rural science students is not found significant. Thus, the hypothesis is accepted.

(vi) The observed mean difference between free from superstitions, reasoning and logical ability, problem solving ability, cause finding ability, curiosity and scientific temper of senior secondary urban and rural science students is found significant. Thus, the hypothesis is rejected.
Hypothesis -2

The hypothesis that there is no significant difference between scientific creativity of senior secondary science students in terms of group, sex and locality is tested by calculating C.R. value for PCM and PCB groups, Boy and Girl & Rural and Urban senior secondary science students. The following results are found-

(i) The observed mean difference between fluency, flexibility, originality and scientific creativity of students of PCM and PCB group is not found significant. Thus, the hypothesis is accepted.

(ii) The observed mean difference between fluency, flexibility, originality and scientific creativity of senior secondary boys and girls science students is found significant. Thus, the hypothesis is rejected.

(iii) The observed mean difference between fluency flexibility and scientific creativity of senior secondary urban and rural science students is found significant. Thus, the hypothesis is rejected.

(iv) The observed mean difference between originality of senior secondary urban and rural science students is not found significant. Thus, the hypothesis is accepted.

Hypothesis -3

The hypothesis that there is no significant difference between scientific temper of high and low scientific creative students in terms of group, sex and locality, is tested by calculating C.R. value for PCM, PCB group, boy, girl, urban & rural senior secondary science students. The following results are found-

a. The observed mean difference between scientific temper of high and low scientific creative students of PCM, PCB group, boy
students and urban science students, is not found significant. Thus, the hypothesis is accepted.

b. The observed mean difference between scientific temper of high and low scientific creative senior secondary science girl students and rural science students is found significant. Thus, the hypothesis is rejected.

**Hypothesis -4**

The hypothesis that there is no significant correlation between scientific temper and scientific creativity of senior secondary science students is tested by calculating correlation between six dimensions of scientific temper-scientific information, free from superstition, reasoning and logical ability, problem solving ability, cause finding ability, curiosity & sum of these as a whole and scientific creativity of senior secondary science students. The following results are found-

(a) The observed correlation between scientific information and scientific creativity, free from superstitions and scientific creativity, reasoning & logical ability and scientific creativity and cause finding ability & scientific creativity of senior secondary science students is found significant. Thus, the hypothesis is rejected.

(b) The observed correlation between problem solving ability and scientific creativity & curiosity and scientific creativity of senior secondary science students is not found significant. Thus, the hypothesis is accepted.
Conclusions

On the basis of statistical analysis and findings of the study or by testing the hypotheses as per objectives formulated for the study following conclusions have been drawn-

1) PCM & PCB group students are found equal on three dimensions of scientific temper i.e. scientific information; free from superstitions and curiosity. Hence, PCM and PCB groups are found equal in general information regarding general science, daily life scientific observations, scientific vocabulary, scientific concepts, belief in superstitions and curiosity at senior secondary level but PCM group students are found having significantly higher reasoning and logical ability, problem solving ability, cause finding ability and scientific temper as compare to PCB group students. Therefore, it seems that PCM group students have much more ability to solve problems and having much reasoning and logical thinking as compare to PCB group. PCM group students are also more able to find causes of daily life scientific effects.

2) Boy and girl science students are found equal on free from superstitions, reasoning and logical ability, problem solving ability and scientific temper. Girl science students have significantly higher scientific information and cause finding ability as compare to boys but boys have higher curiosity than girls. It exhibit that girl students are higher on general information regarding general science, daily life scientific observations, scientific vocabulary and scientific concepts and much more able to find causes of daily life scientific effects as compare to boys.
(3) Urban and rural science students are found equal on scientific information but free from superstitions, reasoning and logical ability, problem solving ability, cause finding ability, curiosity and scientific temper of urban students are found significantly higher than the rural students. Thus, Urban and rural students are equal in general information regarding general science, daily life scientific observations, scientific vocabulary and scientific concepts at senior secondary level but rural students are more superstitious than urban students. Also, urban students have more reasoning and logical thinking, problem solving ability, cause finding ability compare to rural counterpart.

(4) PCM & PCB group students are found equal on the all dimensions of scientific creativity i.e. fluency, flexibility, originality and scientific creativity as a whole. Girl science students have significantly higher fluency, flexibility, originality and scientific creativity as compare to boy science students. Rural science students found to have significantly higher fluency, flexibility and scientific creativity in comparison to urban science students but originality of urban and rural science students is found same.

(5) High and low scientific creative students of PCM & PCB group have same scientific temper. Low scientific creative girl students have slightly higher scientific temper in comparison to high scientific creative girl students but high and low scientific creative boy students have same scientific temper. High scientific creative rural students have significantly higher scientific temper in comparison to low scientific creative rural students but high and low creative urban students have same scientific temper.
(6) There exist a very low but significant positive correlation between scientific information & scientific creativity of senior secondary science students. This shows that students’ scientific creativity slightly increase with increment of general information regarding science, daily life scientific observations, scientific vocabulary and scientific concepts and vice-versa.

(7) There exist a very low but significant positive correlation between reasoning & logical ability and scientific creativity of senior secondary science students. It may be inferred that scientific creativity shows slightly upward movement with increment in the reasoning and logical ability of the students and vice-versa.

(8) There exist a very low but significant positive correlation between cause finding ability & scientific creativity of senior secondary science students. It may be concluded that scientific creativity slightly increases with the increment in the cause finding ability of the students and vice-versa.

(9) There exists a very low but significant negative correlation between free from superstition and scientific creativity of senior secondary science students. It shows that scientific creativity is slightly decreased with increment in free from superstitions of the students and vice-versa.

(10) No significant correlation between problem solving ability & scientific creativity, curiosity & scientific creativity and scientific temper & scientific creativity of senior secondary science students is found.

(11) Values of dimensions of scientific temper could be predicted on the basis of scientific creativity as a predictor. Three dimensions of scientific temper i.e. Scientific information, reasoning and
logical ability and cause finding ability shows upward slope with increment in scientific creativity. Oppositely, rest of three dimensions of scientific temper i.e. Free from superstitions, problem solving ability and curiosity shows downward slope with increment in scientific creativity. However, scientific temper as a whole shows a slightly downward slope with the increment in scientific creativity.

**Educational Implications**

The study may be said to have implications for science education in particular and other disciplines in general regarding the relevant aspects of issues; for teacher, teacher educator, administrators, researcher workers, curriculum developers and not the least, the students. It will be worthwhile to present some such implications here –

1. Scientific temper is a refine human nature and a major outcome of the science teaching and learning. Researcher, in the present study has developed a standardized test for measuring the scientific temper of the students. This test may be useful in measuring students’ scientific temper and used in science talent search programme.

2. PCM group and urban science students have found higher scientific temper in comparison to PCB group and rural science students. Thus, there is a need to foster scientific temper among PCB group and especially in the science students of rural areas. It will be better to organize various co-curricular activities such as science fair, science exhibitions, scientific debate; science club etc. and use of inductive inquiry training model, concept attainment model, project method, problem solving method, Brain
storming and programme instruction in teaching rather than conventional method of teachings especially in rural areas. Use of teaching-learning materials, ICT and emphasis on learning by doing may be useful in fostering scientific temper among science students especially for rural students.

3. As we know, science is the product of creative thinking. The development of creative genius of our youth should be of prime importance in our education system. Thus, it is therefore, a great responsibility to foster this ability to the maximum of the individual’s potential. Result of the study shows that girl and rural science students are more creative than boys and urban students. The girls and rural science students are needed a special attention. These two sections of our society are neglected in science education since long times but result shows that if proper attention and care is given to these sections than it may be useful to the nation and helpful in the advancement of science.

4. Scientific information, reasoning & logical ability and cause finding ability shows slightly upward trend with the increase in the scientific creativity of the students. Thus, if we foster, through teaching and learning process, general information regarding science, daily life scientific observations, scientific vocabulary, scientific concepts, reasoning and logical thinking and cause finding abilities of students regarding daily observing scientific effects and application then the scientific creativity could show upward increment. Hence, if teaching–learning activities include, apart from its regular curricular activities, various co-curricular activities such as organization of science fair, science exhibitions, scientific debates, scientific quiz and
science club, use of problem solving and project methods and brain storming, inquiry training model and concept attainment model, emphasis on numerical based problems, activity based self learning, use of ICT etc. then it will be possible to foster scientific temper and scientific creativity among our students.

Suggestions –

**Suggestion for School Administrators and Teachers**-

1. The elements of convergent and divergent thinking should be continuously stressed and applied to the solution of the problems in classroom and school regularly.

2. Open ended experiments and activities, “Brain storming” and “Imagineering” sessions in the class in which students think, hypothesize and discuss even an unreal problem should be organized to foster creativity.

3. Students should be provided situational-science experiences every day. These are brief situations which may arise from the daily experiences of children in the science classroom or laboratory or field or at home and opportunities for practicing work should be provided in schools.

4. Children are made more sensitive to environmental stimuli.

5. Democratic procedures should be practiced in the classroom.

6. Self-learning should be encouraged.

7. The school and science classroom should have scientific atmosphere.

8. Students should provide opportunities for independent extra-reading, laboratory work, improvisation of apparatus, problem solving etc.
9. Problem solving, Project method, Brain storming, Seminar and Laboratory method should be used in teaching-learning process.

10. Inquiry training, concept attainment and inductive training models may be useful in fostering scientific creativity and temper.

11. School should organize science exhibitions, science fairs, and science quiz and science debate type co-curricular activities.

**Suggestion for Parents**-

1. Parents should provide environment of free expression to the children in the home.
2. Parent should encourage children for questioning.
3. Parents should provide science related magazines to children for boosting their scientific knowledge.
4. Parent should encourage their children to solve their day to day problems.
5. Parents should create democratic atmosphere in the home. Such atmosphere will be useful in infusing a spirit of healthy criticism.
6. For removing the superstitions from the mind of child, the parents should usually put such type of questions as “What evidence or proof have you get for this belief?” This will also develop in them open-mindedness and critical thinking.

**Suggestion for further study**-

In India, scientific temper of science education is remained completely unexplored. Only negligible number of studies has been attempted in this direction, many linked questions and issues remained unanswered while a lot of research studies need to be attempted to solve them. Based on the research experience of the present investigator and
findings of the study some of the suggestions for future research in this area are identified as below-

1. The study may be replicated for various grade levels to confirm the generalizability of the results and conclusions of the study.
2. Researcher may standardize scientific temper tools on other population.
3. Investigation may be extended to other cognitive variables related to science.
4. Research may be extended on factors related to fostering of scientific temper and their impact on different dimensions of scientific temper.
5. Researcher may study on factors related to fostering of scientific creativity and their impact on scientific creativity.
6. Study may extend to scientific temper and personality correlates be made.
7. Investigation may be made on scientific creativity and personality correlates.
8. Research on different dimensions of scientific temper and other cognitive variables related to science may be taken.