

# **DEVELOPMENT OF STRATEGIES TO ENHANCE SCIENTIFIC TEMPER AMONG SECONDARY SCHOOL STUDENTS**

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## AN ABSTRACT OF THE THESIS

### INTRODUCTION

Education is an essential aspect of a person's life. It not only aids in the acquisition of knowledge, but also incepts curiosity in the human beings. A human mind is a curious mind- from discovery of fire to discovery of Artificial Intelligence, curiosity has always helped in pivoting our lives for a better tomorrow. It is this curiosity that has aided the birth and progress of science; the era of science and technology began. In the modern world, science has radically changed men's material environment. It has led to material and non-material development. The development of science and technology has fostered a new intellectual temper known as Scientific Temper. Scientific temper is one of the abilities which helps human beings in rational and logical thinking by following the scientific method and makes an individual scientifically literate. Scientific temper not only helps in searching the truth but is an integral part of one's overall thinking and action. It generally means to accept the truth in its real form without subjecting it to any kind of influence (Kaur and Vadhera, 2018). It is the most important factor in the nation's growth this is the reason that Pt. Jawahar Lal Nehru in 1946 has introduced this term in India and put forth all the efforts in this very direction. He has quoted well the importance of science and scientific temper in the following lines – *“It is Science alone that can solve the problems of hunger and poverty, of ill sanitation and illiteracy, of superstition and deadening custom and tradition, of vast resources running to waste, of a rich country inhabited by starving people”*. Scientific Temper is something that follows the scientific method in its investigation of truth which majorly include observation followed by experiment and then analysis of findings for its verification. Various educationists and scholars have defined scientific temper in various ways from time to time (Pattnaik, 1986; Kalbag, 1991; Hemlata, 1988; Krishnan and Bhuvaneshwari, 1990; The Seventh Five Year Plan, 1985-90; Singh, 1998; Kaur and Vadhera, 2018; Draft Scientific Social Responsibility Policy, 2019). The conclusion of all the definition imply that scientific temper is an individual's ability to use the scientific method as an important part of their thinking process in all the day-to-day activities. It is usually an affective construct and has a direct or indirect linkage to one's personality (Kaur and Vadhera, 2018). Based on related reviews and analysing the nature and definitions of scientific temper, the researcher had identified a total of 8 characteristics which are Healthy Scepticism, Objective Intellectual Honesty, Rationality, Perseverance, Freedom from superstition, Curiosity, Open-Mindedness, Observation of scientific temper. These all characteristics are interconnected and they cannot be perceived in isolated terms. They constitute a cohesive, interrelated, and well-integrated whole.

Pt. Jawaharlal Nehru had introduced the term scientific temper in his much-acclaimed book named *Discovery of India* in 1946. Although Bertrand Russell in 1923 in his book *On education* had mentioned it for the very first time as one of the major aims of education. Even the Indian civilisation has been known for its scientific advancement in the world from ancient times. Nobel Laureate Prof. Amartya Sen's book *The Argumentative Indian* also mentioned this very fact by mentioning that scientific temper has been the hallmark of Indian thoughts since long (Sen, 2006). The very first policy catering to this very notion called the scientific resolution policy was launched in 1958. Realising and witnessing its advantages in 1976, India became the first country to include in its Constitution 'Scientific Temper spirit of inquiry and reform [Article 51-A (h)]'. Four years later, in July 1981 at the Nehru centre Bombay the statement of scientific temper was released. This document articulated the need to inculcate the values of Scientific Temper in the Indian Society to rid the country of its socio-economic ills at that time. The Statement had invoked a lot of criticism in the certain circle of academia (Prasad, 1982; Chadha, 2005). In 2011, an attempt was again made to revisit the 1981 Statement of Scientific Temper named *Scientific Temper Statement Revisited 2011: The Palampur Declaration*. It recognised that the Scientific Temper remained largely confined to rhetorical statements. Sadly even social scientists did not make an effort to refine this concept or operationalise the concept for measuring/gauging Scientific Temper. All the policies after independence Viz. University Education Commission (1948-49), Secondary Education Commission (1952-53), Education Commission (1964-66), Science and Technology Policy 2003 and 2013 and National Education Policy (2020) have identified the importance of scientific temper. NEP 2020 has identified it as one of the most important 21<sup>st</sup> century skill. ...

It is said that we are living in the age of scientific advancement and the technological era. However, calling this age a scientific age just on the basis of the bulk of scientific information gained will be a mistake. When folks with a scientific temperament can address and solve society's problems, age can be considered scientific. (Jahagirdar, N.A.). It is witnessed time and again that India fails to show the characteristics of scientific temperament and easily falls into the trap of believing in godman, magical beliefs, superstition-related activities. This makes us think that besides all these advancements and development India has yet to reach Nehru's desired scientific temper. (Mahanti, 2016). Along with these problems of rising misinformation and fake news is also one of the key factors why there is a need for the resurgence of scientific temper. Akbar and Pal (2020) found that there was a sudden expansion of misinformation during this Pandemic in India and false claims that affected people emotionally also increased

greatly. These are all issues that, in the long term, impair the country's scientific and technical base and function as a major impediment to the development of scientific temper.

There are many hurdles on the way of developing scientific temper like multiple religious beliefs, fight with religion and spirituality, rising intellectual design movement etc. but it is the duty of citizen and policy makers to save this very temper and ensure its development in the young generation for proper growth of nation. The secondary education stage is the most critical stage as the students start to think in an abstract term in this stage of life. Secondary education strives to develop the intellectual, social, and moral traits necessary for democratic citizenship, as well as to prepare young people for job or further study (Secondary Education Commission Report, 1952; Report of Education Commission, 1964-66). The attribute of scientific temper shows children's inherent proclivities, but as they grow older, the usefulness of this feature tends to wane due to ongoing shaping through school science, which has been the major vehicle for spreading NOS (Nature of Science) beliefs (Kaur and Vadhera, 2018). Hence it is Teachers responsibility to ensure that the innate inquisitiveness and critical mindset is not hampered due to any cause.

Usually, scientific temper is considered to be developed through science and Mathematics subjects but even another subject has the potential to inculcate this very domain in an individual. The same is suggested by the Kothari commission (1964-66) and Statement of scientific temper (1981) which said that scientific temper can be developed not only through science but social science as well. Even University Education Commission (1949) has considered language as the most powerful tool for imparting scientific thinking. NCF 2005 has also emphasized the nature of Social Sciences and said that the social sciences, like the natural and physical sciences, offer themselves to scientific inquiry. Hence in the present study researcher has taken all three subjects to develop a scientific temper.

## **REVIEW OF RELATED LITERATURE**

Total 78 Studies have been reviewed for the present study. Out of these total 78 studies, 41 studies (Pattnaik, 1986; Singh, 1987; Dubey, 1992; Pradhan, 1996; Singh, 1998; Tripathi, 1999; Rajammal, 2003; Nadeem & Wani, 2005; Gupta, 2007; Nigam, 2007; Vyas, 2010; Bhatnagar, 2011; Nadeem & Ridwana, 2012; Plessis, 2013; Aezum and Wani, 2013; Aasia and Akbar, 2013; Mudasir and Yatu, 2013; Anbuchlevi, 2014; Bhatta, Netragaonkar, 2014; Maqbool, Mudasir and Zehta, 2014; Anand and Kumar, 2015; Joshua, 2015; Basu & Aslam, 2015; Andrabi, 2015; Kaur, 2015; Nagarathinam & Kumar, 2015; Bhat and Kapri, 2017;

Bhat, 2017; Ridwana, 2017; Nautiyal, 2017; Yadav, 2018; Dar& Ghani, 2019; Thankkur and Bhan, 2019; Jahanger and Dar, 2019; Eswari and Manickavasagan, 2019; Sharma, 2020; Priya, 2020; Nisa, 2020; Gopalkrishnan & Galande, 2021; Kaur and Vadhera, 2021; Biswal and Pandey, 2021) were directly related with the scientific temper while the rest of the studies were related with the terms used synonymously with the scientific temper like scientific thinking, scientific habit of mind and scientific attitude. Total 7 studies (Pritchard, 2005; Thitima & Sumalee, 2012; Foss, 2014; Causey, 2016; Dey, 2017; Singh, 2019; Hyytinen, Toom & Shavelson, 2019) were related to the scientific thinking, 4 studies (Coll and Taylor, 2004; Coll, Taylor & Lay, 2009; Çalik, Çalik & Coll, 2012; Turan and Coll, 2013) were related to scientific habit of mind and 26 studies (Julius, 2016; Yadav, 2011; Patel, 1997; Choukade(2014; Budiharti & Waras, 2018; Bagavathy, 2015; Sari, Sudargo & Priyandok, 2018; Price & Lee, 2013; Erdogan, 2017; Panneerselvam&Muthamizhselvan, 2015; Suastra and Ristiati, 2019; Gumilar, Wardhini & Lisdiana, 2020; Dewi Saputri, Nurkhalissa & Akhlis, 2020; Govindrajan, 2014; Sreekumar, 2015; Chakraborty, 2015; Meenakshi and Vasimalairaja, 2016; Ahuja, 2017; Revati and Meera, 2017; Singh and Bai, 2017; Kundu, 2018; Thory, 2018; Shetty, 2016; Rasani S., 2017; Ahmed, 2007; Pyari, 2009) were done in the area of scientific attitude. Out of all these, very few studies have been done in qualitative type while most of the studies are of survey type and a considerable amount of studies have been done in experimental type.

The analysis showed of the above literature showed that the intervention program did help in the development of scientific temper but most of the research was done either in science or a separate program is developed for this. The researcher couldn't come across any study in which the program is implemented in an integrated way thattoo by taking up social science as well. Hence, the researcher has taken up this study wherein the researcher will try to develop certain generic strategies in an integrated approach to develop scientific temper among secondary school students as in thisstage students started to think critically and rationally. For this, the researcher has taken up three subjects of class 9<sup>th</sup> viz. Science, Mathematics and Social Science as various studies suggested that social science has the potential to develop scientific temper as well.

## **RATIONALE OF THE STUDY**

The goal of instilling scientific temper is critical to the advancement of science and its application in the development process. Scientific temper should be instilled in all students, not only science students, because scientific temper is not limited to science disciplines or rules, hypotheses, and formulae. Scientific temper is generic in nature, and it may be instilled through

any subject such as social science, mathematics, languages, physical education, painting, art and craft, and so on. However, subjects that are more factual in nature will be more convenient and easier for the development of scientific temper. Hence in this study subjects based on factual information and logic like Science, Social Science and Mathematics had been selected. As we all know secondary schooling is a critical period. It serves as a connection between primary and secondary education. Primary education is designed to meet the bare minimums for survival, but secondary education prepares a person to participate fully in a complex society. Hence, the researcher has considered the secondary students for the present study. As class 10<sup>th</sup> students are going to face board examination so this time is very important for them which may be one of the factors for the authorities for not allowing the experiment in that stage especially so the researcher has taken only 9<sup>th</sup> standard for the experimentation. From the review of related literature, it was found that very rare studies have been done on scientific temper and in that also most of the study was related to measuring scientific temper that too by considering very few components of scientific temper. The researcher could come across only one study that was done to develop a package that too in science subject only. But as scientific temper is considered as a temper of a free man so it can be inculcated by using any subject with this assumption the researcher has decided to develop the strategies to enhance the scientific temper among secondary school students by taking Science, Mathematics and Social Science subjects of GSHSEB schools.

## **STATEMENT OF PROBLEM**

Development of Strategies to Enhance Scientific Temper among Secondary School Students.

## **OBJECTIVES**

1. To develop strategies to enhance scientific temper among the secondary school students.
2. To implement the developed strategies on the secondary school students to enhance their scientific temper.
3. To evaluate the effectiveness of the developed strategies in terms of enhancement of scientific temper among secondary school students.
4. To evaluate the effectiveness of the developed strategies in terms of the reaction of secondary school students towards the strategies.

## **HYPOTHESES**

The following null hypotheses were tested at the 0.01 level of significance.

H<sub>01</sub>: There is no significant difference between the mean pre-test and post-test scores of scientific temper between secondary school students those did not expose to the developed strategies to enhance scientific temper.

H<sub>02</sub>: There is no significant difference between the mean pre-test and post-test scores of scientific temper between secondary school students those exposed to the developed strategies to enhance scientific temper.

H<sub>03</sub>: There is no significant difference between the mean post-test score of scientific temper between secondary school students those exposed and whose did not expose to the developed strategies to enhance scientific temper.

## **EXPLANATION OF THE TERMS**

Secondary school students – It includes students who are studying in classes IX and X.

Strategies – In this study strategies were referred to the prepared plan involving a sequence of steps designed to enhance the scientific temper considering the components of scientific temper through the instructional process.

## **OPERATIONAL DEFINITION OF THE TERMS**

Scientific temper: Scientific temper is the score secured by a student in the scientific temper scale developed by the researcher.

Enhancement of Scientific Temper: It is a significant difference between the pre-test and post-test scientific temper scores of the experiment and control groups.

Effectiveness: Effectiveness is the significant difference in the post-test scores of the experiment and control groups in scientific temper.

Effectiveness in terms of reaction: Effectiveness in terms of reaction is the overall positive reaction ( 3.5 and above) of students towards strategies to develop scientific temper in a Likert type 5 point reaction scale developed by the research.

## **DELIMITATION**

The study is delimited to English medium school following GSEB syllabus in Vadodara city. In this study, Secondary School is delimited to standard IX only. The study is also delimited to



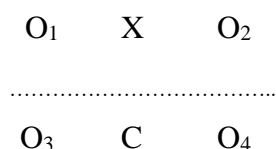
Science, Mathematics and Social Science subjects. The scientific temper delimited to eight components viz. healthy scepticism, objective intellectual honesty, rationality, perseverance, freedom from superstition, curiosity, open mindedness, observation.

## METHODOLOGY

The present study was experimental in nature. The methodology includes design of the study, variables of the study, population, sample, tools of data collection, procedures of data collection and data analysis.

## DESIGN OF THE STUDY

The present study was experimental in nature and the researcher has taken naturally formed intact group i.e. the whole classroom of class 9 of two schools non-randomly, only the control of the various parameters had been done thus the design of the study is quasi-experimental research design. Considering the typical nature of the study, a Pre-test post-test non-equivalent group design of the quasi experiment had been selected for the study. The experimental and control group were made equivalent on the basis of scores achieved in Scientific Temper Scale developed by the researcher. The design of the study is presented as follows (Campbell and Stanley, 1966).



Where O<sub>1</sub> and O<sub>3</sub> - pretests

O<sub>2</sub> and O<sub>4</sub> - post-test

X stands for experimental group and

C stands for control group

Following the design, two groups were selected conveniently as experimental and control groups. The initial level of scientific temper had been checked prior to the experimentation by using self-made Scientific Temper Scale. On the basis of the obtained scores in the scale, the experimental and control group were made equivalent. The treatment i.e. teaching through developed strategies to enhance scientific temper was given in the experimental group only while the control group was taught through the traditional method without applying any kind of specific intervention.

## **VARIABLES OF THE STUDY**

In the present study independent variable is the developed strategies to enhance scientific temper and the dependent variable is scientific temper.

## **POPULATION**

The population for the present study was composed of all the students of the English medium secondary schools in Gujarat state affiliated to GSEB (Gujarat Secondary and Higher Secondary Education Board) during the year 2019-20.

## **SAMPLE**

Two English medium GSEB affiliated secondary schools were selected with convenience from Vadodara district for the experimentation. Both the selected schools were considered equal in standards as both the schools were affiliated to the same board and located within the city area. The selected schools were University experimental English medium school and Vidyakunj High School in Vadodara. Out of these two schools, the former one was selected for the experimental group and later one was selected for the control group. Standard IX classes of both the schools had the strength of more than 45 students. These two groups were made equivalent on the basis of pre-test score of scientific temper scale. In this way, total of 64 students, 32 from the experimental and 32 from the control group formed the sample of the study. Students of the experimental group were taught through developed strategies in an integrated way while the students of the control group were taught through the usual traditional method.

## **TOOLS OF DATA COLLECTION**

Following tools were prepared by the researcher and used for the collection of data.

**Scientific temper scale:** The scientific temper scale was developed and standardised by the researcher herself which was meant for the secondary school students exclusively. Total of eight components of scientific temper were identified after a thorough study of the topic and analysing the review of related literature. It had 32 items. All the items in the scale have been arranged in the sequential order with eight components viz. healthy skepticism, objective intellectual honesty, rationality, perseverance, freedom from superstition, curiosity, open mindedness, observation from 1 to 32 having four items in each component respectively. Each items having response ranging from 1 to 5. The response which shows the highest level of scientific temper was assigned the value of 5 while the lowest level represented with 1. In this

way the minimum and maximum score in the scientific temper scale varies from 32 and 160. For validity content and factor validity were taken out. The reliability of the scientific temper scale was established by using two types of reliability methods which are Split Half reliability and Cronbach Alpha reliability. In both the reliability methods the tool was found to be highly reliable with a score of 0.75 and 0.79 respectively.

**Reaction scale:** The researcher has prepared a five-point Likert type scale to know the reaction of students towards the developed strategies to enhance scientific temper. There was total 30 statements in the scale related to different aspect of their experiences during the execution of strategies and teaching learning. Each statement has five-point ratings Viz. strongly agreed to strongly disagreed. The weightage for ratings of the scale are 5,4,3,2,1 respectively for the SA, A, UD, D, SD. In this way the highest score one could get was 150 and lowest was 30. The students were asked to read each statement carefully and mark a tick on a suitable option for each statement.

## **DEVELOPMENT OF STRATEGIES**

In the present study, strategies were developed by the researcher to enhance the scientific temper among secondary school students by teaching Science, Mathematics and Social Science subjects. For this purpose first of all the identification of chapters to be taught was done of these three selected subjects. After that content analysis was done and the researcher has divided the chapters into various topic and subtopics so that the each recognised scientific temper components can be assign exclusively to subtopics. Then the researched has developed integrated strategies for all these selected topics. The strategies included ICT enabled learning, story telling, Questioning, Timeline, Debate, Discussion, Role play, News/Movie analysis, Worksheet. Once all the things have decided the researcher has prepared the final lesson plan to be used for teaching learning by using Herbatian steps.

## **IMPLEMENTATION OF STRATEGIES**

The developed strategies were implemented in the experimental group for the teaching of Science, Mathematics and Social Science subjects with the chapters common in both experimental and control group. The selected topics those could develop scientific temper in all the subject were taught by the researcher in the allotted classes that varies 3-5 classes in a week.

## **DATA COLLECTION PROCEDURE**

For the purpose of data collection two tools scientific temper scale and reaction scale were developed by the researcher. As the study is pre-test post-test non-equivalent group design hence the data were collected at the beginning and at the end of experimentation. First of all, scientific temper scale was implemented on both the groups as a pretest to know the initial level of their scientific temper and to make them equivalent. After that the developed integrated strategies were implemented in the experimental group whereas the control group were taught through regular teaching learning process. At the end of second semester scientific temper scale as a post-test was administered again on both the groups. To know the reaction of developed strategies reaction scale was also administered on the experimental group.

## **DATA ANALYSIS**

Considering the nature of the Sampling method, collected data were analysed using mean, SD, Mann whitey U test, frequency percentage and intensity index. All the analyses were done using SPSS 20.0 (Statistical Package for Social Science) and MS Excel.

## **MAJOR FINDINGS**

Following major findings were drawn on the basis of data analysis and interpretations.

1. No significant difference was found among the mean pre-test and post-test scores of Scientific temper of control group those were taught in traditional method of teaching. This was also found in case of all the eight components of scientific temper viz. healthy scepticism, objective intellectual honesty, rationality, perseverance, freedom from superstition, curiosity, open mindedness and observation. In other words, traditional method of teaching did not help in enhancing scientific temper either as a whole or in any of it's components.
2. Post-test score of Scientific temper of experiment group those were taught through developed strategies was found significantly higher than their pre-test score in scientific temper. This was also found in case of all the eight components of scientific temper viz. healthy scepticism, objective intellectual honesty, rationality, perseverance, freedom from superstition, curiosity, open mindedness and observation. In other words, teaching through developed strategy helped in enhancing scientific temper as a whole and in all the eight components.
3. Post-test score of Scientific temper of experiment group those were taught through developed strategies was found significantly higher than the post-test score of Scientific

temper of control group those were taught in traditional method of teaching. This was also found in case of all the eight components of scientific temper viz. healthy scepticism, objective intellectual honesty, rationality, perseverance, freedom from superstition, curiosity, open mindedness and observation. In other words, teaching through developed strategy was found superior and effective in enhancing scientific temper among secondary students in comparison to the traditional method of teaching.

4. The developed strategy was found effective in enhancing scientific temper among secondary students in terms of favourable reaction of students towards different aspects of strategies.

### **EDUCATIONAL IMPLICATION OF THE PRESENT STUDY**

Finding of the present study showed that the implementation of strategies does help in the enhancement of scientific temper of students. In the traditional teaching the same had failed to happen. In the present study no complex words have been employed and only the available resources have been used to teach the students during the implementation phase. The only thing that made this whole process successful was the deliberate attention to the objective of enhancing the scientific temper. It was made simpler by identifying the specific domain that comprised the whole of scientific temper. In this way, the finding is very useful for all the stakeholders of the education system.

Generally, it is believed that for implementing any such strategies a special environment, resources, funding and extra time etc. are needed while in the present case researcher has used only the available resources. Nowhere in the whole process, the researcher has disturbed the traditional teaching going in parallel. In fact, all the strategies were integrated with the normal teaching in such a way that no extra time was needed for the same. Extensive use of questioning was used for the success of the experiment so that the inherent inquisitiveness of the students can be ignited. Besides that, use of ICT tools for the presentation of content and various option like time line, drawing, debating, discussion etc. were used for the evaluation and expressing view of students. The environment was created in such a way that no student feel fear and shyness. They all were given ample opportunity to work in group to overcome the fear in them and to make them open to various kind of experience and difference in opinion. In this way, it can be said that even the tiny efforts and little deliberation towards the goal of enhancing scientific temper can do miracle in achieving the goal of development of scientific temper.

## **SUGGESTIONS FOR FURTHER RESEARCH**

The present study was done with some of the delimitations and limitations. On the basis of the experiences gaining while doing this very research, the researchers had identified few of the areas where the further researches can be performed by the researchers who will have willingness to do the research in this area. They suggestions for further studies are listed below:

- Similar kind of experimental study may be done where the strategy can be formed by taking language into consideration.
- Similar kind of experimental study may be conducted by taking different level of school children like primary, higher secondary.
- Longitudinal studies may be conducted for the period of 2-3 years where the effect of implemented strategies may be observed every year and at the end of all years to see the cumulative effect.
- In the similar experimental study the effect of demographic variables like gender, location, socio economic status etc. may also be assessed.
- Similar kind of study may be done by employing qualitative approach.
- The awareness of scientific temper of the teacher, parents, and school administrators may also be assessed.
- Similar kind of study may be conducted by taking different kind of boards of education like state board, IB and CBSE.
- Survey of level of scientific temper of students at different level and stream may be studied.
- The similar kind of study may be done in the different geographical locations.
- Correlation study with the achievement of different subjects may be conducted.
- Similar kind of study may be performed with the disadvantage group like tribal.
- Similar kinds of study may be performed with the adult learner under continuing education.
- Attitude of various stakeholder of education towards scientific temper may be studies.
- Similar kind of study may be conducted by implying different experimental designs.

## **CONCLUSION**

A scientific temper is a scientific bent of mind that not only opposes rigid thinking but also motivates one to ask questions in order to find logical and rational answers. It is so critical that

it is included in our fundamental duty; even the recently released NEP 2020 recognised it as one of the most important 21st-century skills. The present study was conducted by keeping this very perspective in mind. The study revealed that the implementation of developed strategies proved useful in the enhancement of scientific temper among secondary school students. The differences in the level of scientific temper were clearly visible in the scores of students who were taught by the traditional vs. integrated method. Usually, it is considered that this very temperament can only be developed through science subjects, although this study advocated that it is not the case. This task of the development of scientific temper can be done using any subject. In this case, the researcher used three subjects to accomplish the same goal: Science, Mathematics, and Social Science. Even the reaction of students towards the developed strategies was found to be favourable, which showed that they love to learn in new ways. According to the students' reactions, the strategies encouraged them to think scientifically and aided in the development of their natural inquisitiveness. It made them more confident and fearless in asking the question. At the end of the course, it was also observed that students started to find new information on their own and started discussing it in the class. Overall, the response was very positive and the result proved to be significant in enhancing the scientific temper of secondary students. The result of this study could be beneficial for all the stakeholders of the education system, be it a teacher or policymakers. It proves that even with very little conscious effort, improvement can be witnessed.