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Scientific Temperament of High School Pass Students: Reflections for Future

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Abstract

To develop the Scientific temper of all students and individuals in general, has always been one of the cherished goals of education and its importance has been highlighted by various policy documents and government initiatives for many-many years now. This paper assessed the scientific temperament among high school pass students who are currently pursuing the teacher education programme. The researcher modified the Scientific Temper Scale by N.A. Nadeem and Showkat Rasheed Wani to suit the need of this study. The tool was modified to include subjective questions so that the researcher does not end up labelling the participants as having low or high scientific temperament but some insights could be gathered about the gaps in our education system and implications can be derived for future.

Keywords: Scientific Temperament, Science Education, Teacher Education

Introduction

The importance of developing scientific temper in every citizen of India has been emphasized by Pandit Jawaharlal Nehru as early as 1946 in his book "Discovery of India" wherein he gives a description of scientific temper in the following words:

"The scientific temper points out the way along which man should travel. It is the temper of a free man. We live in a scientific age, so we are told, but there is little evidence of this temper in the people anywhere or even their leaders. [What is needed] is the scientific approach, the adventurous and yet critical temper of science, the search for truth and new knowledge, the refusal to accept anything without testing and trial, the capacity to change previous conclusions in the face of new evidence, the reliance on observed fact and not on pre-conceived theory, the hard discipline of the mind—all this is necessary, not merely for the application of science but for life itself and the solution of its many problems."

The description makes it clear that scientific temper is about an attitude of open mindedness, rational thinking, curiosity, questioning the existing knowledge to discover new knowledge and adopt a scientific approach in solving one's life problems. The scientific temper is thus not limited to students or practitioners of science but should be a fundamental aspect of everyone's personality. Its application is not limited to domains of science but transcends into all disciplines and life in general. However, science education should specifically address the need of developing the scientific temper among all children right from the beginning. In the last few decades, various government and non-government

initiatives have emphasized and attempted to address the need of developing scientific temper in all citizens. One of the first major programme was the launch of Vigyan Mandir experiment by Pandit Nehru in year 1953. The programme was developed by Council of Scientific and Industrial Research (CSIR) and aimed to disseminate scientific information among rural population. Several scientific journals in various languages were published through CSIR so that masses could connect with science. The National Council for Science and Technology Communication (NCSTC) was established in 1982 following the sixth five- year plan of government of India. The NCSTC strived to build scientific thinking and informed decision making by creating awareness, promoting communication, providing training in science and technology communication and conducting outreach activities. India also witnessed the establishment of IITs and Research labs gradually. Several other initiatives such as celebration of National Science Day, organizing National Children's congress and National Teachers Congress and establishment of awards for research in science have also taken place.

The educational policies and curricular frameworks have reiterated the need of developing scientific temper in different words. Scientific temper is a broad concept and includes multiple dimensions. Researchers have attempted to define and assess scientific temper using various tools. The tools available for assessing scientific temper in India are popularly in the form of attitude scales. A brief overview of some of these tools which were considered before finalizing the tool for current study is presented under Literature Review section.

Objectives

- To assess the scientific temperament of high school pass students who are currently pursuing the teacher education programme.
- To find out the gaps and reflect upon future course of action for science education.

Literature Review

The assessment of scientific temper in India has been done by different researchers most commonly by using the standardized scales developed by popular agencies like National Council of Educational Research & Training (NCERT), New Delhi and National Psychological Corporation (NPC), Agra or scales published in research journals. These scales offer the advantage of being readily available to the researchers and most researchers find it very convenient. Some of these scales are Gakhar & Kaur (1985); Grewal (1990); Bhagwat (2006); Nadeem & Showkat(2008);Misra (2008), Bajwa & Mahajan (2012) and Khan & Siddiqui (2020). The common feature of these scales is that they require the participants to rate their opinion about several statements representing the scientific temper of participants. The score obtained by the participants is used to classify them as possessing varying degrees of scientific temperament. The scales have also been used in several researches to compare the scientific attitude of participants based on gender, socio-economic status and urban or rural back ground etc. The studies have also attempted to establish the correlation of scientific temper with academic achievement, emotional intelligence and problem-solving abilities of the participants.

Andrabi (2015) investigated scientific temper, emotional intelligence, and academic achievement among tribal and non-tribal adolescents of Kashmir. The sample of the research study included tribal and non-tribal adolescent (male/female) students of 9th class in Government schools of Anantnag and Kupwara Districts of Kashmir India. It was found that tribal and non-tribal adolescents differed

significantly with respect to scientific temper, emotional intelligence, and academic Achievement but there was no significant difference between male and female adolescent students on scientific temper. The study by Thakur & Bhan (2019) researched the scientific temperament among Secondary School Students with respect to their gender and reported that scientific temperament was higher among male students as compared to the females. Kour(2015) compared the scientific temper of high and low achieving adolescent girls in the various districts of Srinagar. The study used the tool developed by Nadeem and Wani and found that while there is no difference between the two groups on the dimensions of open-minded ness and aversion to superstition; the high achieving girls scored high on the other dimensions such as curiosity, objectivity and rationality of the scientific temperament scale.

The review of literature also pointed out that there is a lack of instruments with subjective questions related to scientific temperament. Most of the studies have failed to gather insights about the gaps and possible reasons for lack of scientific temperament. In the current study, the researcher used the Scientific Temperament Scale developed by Nadeem and Wani (2008), as a reference and modified it by adding subjective dimension to its several statements. Some statements were also eliminated and modified after expert validation and pilot testing.

Sample

The sample consisted to 90 students of the teacher education programme (B.El.Ed. programme) who had completed their first year. These students had studied science at least till class X and had a chance to revisit their school science in the first year of the B.El.Ed. programme. The sample was purposive in nature as the researcher, being a teacher educator in the same programme had an easy access to them. Also, the researcher deliberately wanted to understand and address the needs of this particular group as these students had studied science till class X and hence are expected to be scientific literate and possess scientific temperament. Also, they would be prospective teachers in schools and hence are likely to influence the students they will teach in future. The researcher did not merely want to label them as having low or scientific temperament but wanted to reflect upon their needs so that changes can be suggested for the future. Being a teacher educator in the same course, it is easier for the researcher to suggest and implement changes for this particular group, however the research has potential to provide directions for the school education in general.

Data Collection

After doing the thorough review of the tools available for assessment of scientific temperament, the researcher selected the Scientific Temperament Scale developed by Nadeem and Wani(2008). The scale consisted of 50 statements representing the five dimensions of scientific temperament- Objectivity, Rationality, Curiosity, Open mindedness and Aversion to superstition. In the current research, the researcher not only wanted to provide a score of scientific temperament to the participant but wanted to find the specific areas of improvement. One of the biggest challenges with the use of quantitative scales is that participants tend to make educated and acceptable choices rather than provide their real opinions and experiences associated with each statement. Each statement of the scale was carefully examined and some of them were selected the for a more detailed examination. A subjective question was added to these statements so that the participants get a chance to express themselves

through their experiences. A list of 10 subjective questions was thus added to the test as a separate section.

Adding the subjective questions increased the time taken for the test and hence to avoid disinterest of the participants, some of the statements were removed from the test. This was done with the help of three expert reviews and a pilot test. The items that were removed were either repetitive or ambiguous.

The data was collected by creating a google form and sending it to more than 200 students from different colleges. The form was submitted by 115 participants over a period of one week. Only 90 participants had responded on both the sections and were considered for final scoring and analysis.

Each objective statement carried one mark for the correct response and each subjective statement consisted of 2 marks. While the score of objective section was generated automatically in the google form, the scoring of subjective section was done manually. Each response with an affirmative response and correct example was given a score of 2. Only affirmative responses without examples were given a score of 1 and the negative responses were given a score of zero. A total score was obtained for each participant by adding the scores of objective and subjective sections.

Analysis

The original scale by Nadeem & Wani had categorised the participants into five categories. However, in the current research only three categories were used- Low scientific temperament, Moderate scientific temperament and High scientific temperament. The discussion with experts suggested that its difficult of distinguish between categories such as poor scientific temperament and below average scientific temperament.

The lowest score obtained in this study was 10 out of 50 and the highest score was 47 out of 50. The mean score obtained for a sample of 90 students was 24.8 and the standard deviation was 6.5. Using the statistical principal of normal distribution, following scoring ranges were used for classifying the participants as having low scientific temperament, moderate scientific temperament and high scientific temperament.

Score	Scientific Temperament
0-18	Low
19-31	Medium
32-50	High

Qualitative Analysis

The qualitative analysis involved reading the responses of all the participants for each question and tabulating the responses that indicated a gap and need for reflection for future course of action. Some of the key responses for each subjective question are discussed below.

Q1. How often do you watch programmes on National geographic, Animal Planet and Discovery Channel or science related YouTube channels and discuss with your friends? Write about one such episode briefly and the channel where you watched.

The responses to this question indicated that most of the students do not have interest in watching science related programmes on television. The ones who watched these programmes have mentioned only two programmes stupid science, man vs wild and that too occasionally. One of the students reported that she watched some interesting videos related to life on other planets, movement of stars and blackholes but when discussed that with her friends and teacher, they did not take much interest as they had not watched these videos. This suggested that our science classrooms should build space not only for watching these programs related to student's interest but should allow encourage discussions around them.

Q2. Do you like/ dislike to go on field trips and educational tours and relate your observations with your course. Discuss the observations made during your last field trip.

Many students reported that they like to go on field trips but the only places they have ever visited are Nehru Planetarium and National Science Centre in the school. The visits do not happen more than once or twice a year and students have very little to learn from these. The teachers should explore more such opportunities and encourage freedom of observation and discussion. Also, it is important to sometimes visit the same place regularly to make meaningful observations. The students could be encouraged to visit nearby parks, water bodies. forests, hills, farms, research centres etc. and not necessarily wait for educational trips organized by the school. It is important to develop an attitude of inquiry about their surroundings rather than merely visiting a place.

Q3. Do you like/dislike to participate and visit in science fairs, science exhibitions and science clubs. Give an example of your learning (if any) from one such activity.

The response to this question suggested that students have some exposure of visiting science fair and exhibitions but most of them have not got opportunity to be in science clubs. Two students mentioned that they were part of the astronomy club in the school for two years but did not find it very useful. The club had shown some films on space and organized onetime event of star gazing. The students who agreed to have participated in science fairs and exhibitions have given very repetitive examples of projects such as showing a volcanic eruption, making a wind mill, electricity from traffic lights etc. It appears that science fairs, science exhibitions and science clubs fail to encourage innovative thinking and generation of ideas.

Q4. Are you keen to conduct experiments and do science projects beyond the prescribed syllabus? Give one example of designing a new experiment or taking a science project besides the syllabus.

None of the students have conducted experiments beyond the prescribed syllabus. The project work was mentioned by students as part of class XII curriculum (only those who had chosen science stream) but the examples that students have mentioned fail to depict any new ideas. The students have done them to fulfil the requirement of curriculum only.

Q5. If you do not get desired results while doing an experiment, you prefer to manipulate my data before showing to the teacher. Or you report your results honestly and try to find the reasons for deviations from the desired result. Give an example and reason to support your answer.

More than 50 percent students have agreed that they report the result honestly to the teacher. The teacher or the lab staff usually help them identify the problem and get the desired result. Some students who manipulated or copied results from their friends said that it was too risky to report the wrong result at the time of board examination and hence they decided to manipulate. The responses of the students highlight that in our education system, there is a lot of emphasis on verification of the known.

Q6. Do you like to discuss and debate about the latest inventions and research in science and technology that you read from newspaper or any other source? Give one example.

Only few students have reported reading about latest research inventions and technology. Although they have responded in "No" about their interest, many of them have given examples of reading and discussing about corona virus and covid-19 vaccine. Some of them have mentioned that they read and discuss only those news items that are related to them. This suggests that reading and discussing about news related to research and inventions in science and other socio-scientific issues need to be consciously incorporated in our classes.

Q7. Do you try to find reasons for breakdown of appliances in your home and fix them? Give one example.

Only 20 out of 90 students have mentioned that they are like to find the reasons behind breakdown of appliances and fix them. It is interesting to note that all 20 of them have mentioned that they have sometimes fixed an appliance like a cooler, mixer, cycle etc but with the help of their father or elder brother. The point to ponder over here is that, does our education system have an inherent gender bias when it comes to learning science? Does it also reflect in their daily -life problem solving and choice of career? It is also to be noted that the entire sample consisted of girls as B.El.Ed. programme has girls' students only.

Q8. Do you question religious beliefs and customs in your home if you find them irrational? Give one example and reason to support your choice.

Many participants reported that they question (only 'politely' or 'sometimes') some of the religious beliefs or customs. The common examples were not washing their head on certain days, doing charity on the day of eclipse, changing the way if a black cat cross them. However, they have reported to reconcile to their parents' wishes due to respect. Also, some of the students themselves liked to follow these customs as according to them it might have some scientific reason which is not known to them. A few have mentioned to have observed bad effects by following them.

The responses of the students indicate that they might understand that certain beliefs are not scientific but they are okay to follow them as it is harmless. In the words of one student, "I don't see the need to question our rituals as certainly following them has no harm. If at all they can do anything, it would be good only; then why not follow them"

Q 9. Your mother asks you/ your sister not to visit temple during mensuration. What would be your response to her?

All the respondents being girls in this study have shared their own experience in this relation. Some of them believe that girls are not pure during this time and hence should not visit temples. Two of them mentioned that they are "Sikh" and in their homes, there is no such restriction. Some of them

mentioned that they have given arguments like, “Goddess is also a woman and It’s a biological phenomenon”, However none of them would like to annoy their mother for such a “petty issue”.

Q 10. The local shop keeper asks you to buy a particular brand of cooking oil. What factors would you keep in mind while taking the decision?

Most of the participants have not been able to provide scientific reasons of selecting the cooking oil. Some of them have mentioned that they would consider smoke point, source, type of food being cooked etc for selecting the oil. The responses indicated their family preferences about a particular brand and hence they would not like to agree with the shopkeeper. It indicates that students do not make informed choices based on scientific reasoning in their daily life.

Findings

(1) Based on the scores, the table below represents the number of participants having low, moderate or high scientific temperament.

Score	Scientific Temperament	Number of Participants
0-18	Low	16
19-31	Moderate	60
32-50	High	14

(2) The qualitative analysis has provided an opportunity to reflect upon the gaps in our education system such as

(a) There is a very strict adherence to syllabus in our classrooms and students are not encouraged to watch television programmes or read news related to research and developments science. This might be detrimental to their interest and curiosity in science.

(b) The participants have expressed their willingness to go for field trips but such opportunities are very less.

(c) The experiments and project work focus on verification of the known rather than finding something new. This defies the spirit of inquiry which is one of the important aspects for developing scientific temperament.

(d) The knowledge acquired in the science classrooms fails to help the students in solving their daily life problems.

(e) The study has also pointed towards an inherent gender bias (from the responses to Q7 of subjective section) however further investigation should be done to establish that.

(f) The students have exhibited their aversion to the superstitions but find it difficult to avoid them as it would mean disrespect to the elders in the family.

Implications and Suggestions

The study has highlighted a general lack of scientific temperament in the selected sample. While a score has been assigned to the participants to assess their scientific temperament but the implications of the study emerge from the gaps pointed out by the responses of the participants on subjective section of the tool. The study has clearly highlighted the need to make conscious efforts in our school system as well as teacher education programmes to develop scientific temperament among the students. While the onus of developing scientific literacy and scientific temperament has been associated with the

school education as science is taught as a compulsory subject till class X in our country; the teacher education programmes and institutes of higher education cannot remain oblivious of this responsibility as our higher education and teacher education programmes prepare teachers for the school system. Some of the suggestions that emerge from the study are as follows;

1. The students should be encouraged to bring their prior ideas and beliefs to the classroom right in the beginning of their formal education so that they get an opportunity to challenge and modify them gradually. The source of their beliefs and superstitions lies in their context and hence community outreach on certain issues should be planned.
2. The science fairs and science clubs should not be merely treated as routine requirements of the profession but should be taken in their real spirit. The authorities should allow freedom to students and teachers to work upon their ideas as if scientists are working on their investigations. Collaboration of schools and colleges with research centres such as IITs, industries, hospitals and agriculture research institutes etc could be planned for such activities.
3. The schools as well as teacher education programmes should encourage their students to design and conduct experiments on their own and beyond the prescribed syllabus even if they are not successful. The assessment criteria should focus on the process, development of skills and open mindedness while conducting the experiments rather than conforming to the textbook knowledge only.
4. The discussion and debates about socio-scientific issues related to application of science in daily life should be a regular part of our science classes as scientific temperament is not about having knowledge of scientific concepts only but to be able to solve our life problems with a scientific approach. It is therefore important to focus on the approaches of teaching science rather than the content of science.

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