Science – Technology - Engineering Aspirations of Students in Relation to their Participation in Science Activities, Status of Science Laboratories and Science Classroom Behavior

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Abstract – *STEM is an uprising and most sought after area which holds pertinence for the newer generations, this creates a good opportunity to assess science aspirations among students and understand the factors responsible for its evolution. But after developing an understanding from the previous literature it was found that not much focus has been given to understand science aspirations in light of the practical implementation of scientific principles by the students such as opportunities of inquiry with engagement in science-related activities or experimentation. Therefore, the given study focuses on students' science, technology, and engineering aspirations in relation to their participation in science activities, science laboratory environment (infrastructure and access) and science classroom behavior of students. Participation of students in science activities was studied under four different categories of in school/ out of school and structured/unstructured activities, wherein students were found to engage more with out of school and unstructured activities. Science laboratory environment depicted a poor picture with laboratories highly lacking in terms of infrastructure, accessibility to laboratories was also limited as around 62% of students had never visited science laboratories while others had never participated in the practical performance of experiments. Participation in science activities reflects a positive relationship with aspirations which therefore implicates towards more involvement of students with in school science activities as compared to out of school, especially in rural areas. Also, school administration needs to work more towards the organization of structured science activities for students. In terms of science classroom behavior it seems to build upon that students reflecting highly efficacious classroom behavior do not guarantee long term participation in science hence teachers should use other assessment procedures to judge students value for science.*

Keywords – *STE aspirations, Participation in science activities, science laboratory environment, science classroom behavior*

INTRODUCTION

The government of India is currently riding high on its "Make in India" and "Skill in India" initiatives which are creating a demand for skilled labor especially for those engaged in the fields of STEM (Science, Technology, Engineering, and Mathematics). Keeping in mind the potential surge in the employability of STEM-skilled persons, it is the academic institutions that have to now work towards churning out individuals who are well equipped and versed with scientific and technological advancements. This poses as a great challenge which commences itself from the school level wherein the prime focus is to restructure the whole teaching-learning process to make it more skill oriented and susceptible so that students look forward to participation in science.

But the participation in science of Indian students shows an under representation with only 16% opting for science courses and 15.6% for engineering and technology, and social sciences ruling the stakes with 40% enrollment of students at the undergraduate level [1]. This somehow indicates that lesser number of students is actually aspiring for sciences; studies have shown that students tend to be less engaged in science at higher levels of education despite having a greater interest in science at primary level [2]. Also, most of the evidence suggests that interest in science is significantly formed by the age of 14 years [3, 4]. Therefore, it becomes obligatory to manifest science related aspirations among students from an early age, so that pertinent outcomes in the form of increased participation in science can be targeted in the future.

Theoretically, science aspirations are regulated by the development of science identity among individuals, which is the sense of being in terms of science [5].

Science identity is a well-studied construct which is driven by social interactions, engagement, and competence of students. Science identity evolves with time for an individual and is very well linked to aspirations [3], suggesting the development of science identity among students to ensure persistent participation in science. Science identity is regulated by a large number of factors; the ones which are predominant contributors are parental and family support [6], classroom experiences and attitude towards science [3], teacher expectations [7] and peers sharing similar interests [8]. These factors have also been studied in relation to science aspirations as is evident through various studies [9-11] wherein they have found to give contributory results and negative school experiences have been found to be deterrent in pursuit of science [12],[13].

Another theoretical model from which science aspirations draw upon is the expectancy-value model [14]. According to this model, the educational and career decisions of an individual are associated with how students attain, value and utilize their experiences at school, home in shaping their short term or long termed goals, attitudes, and preferences [15]. Implications of this model for science-technology-engineering aspirations emphasize on the role of interactions (teachers, parents, peers and role models) and participation in science which enable students to value their ability to engage in science. Since learning through inquiry holds prime importance in acquainting learners with lived experiences, therefore, it becomes pertinent to understand the environment being provided to in all aspects of a science classroom (laboratory, classroom, and activities). These factors are also in consonance with social cognitive career choice model [16] which also reinstates the impact of experiential learning experiences in modulating mathematics and science-related career decisions. It specifically thrives on the role of learning experiences (school /home) in shaping career related self-efficacy.

Aspirations have been measured against well-constructed variables repeatedly such as achievement, attitude towards science, family/ teacher expectations, but what has been found lacking majorly are the studies which assess student's participation in school and out of school science activities. Hence, we need to look into the opportunities in terms of participation in science being provided at the school level or at home. Stimulation of students through practical experiences such as participation in science-related activities, science laboratory exposure/ environment and most importantly classroom behavior showcased by a student particularly for science, can reflect upon his competence and curiosity towards the area. Therefore, analysis of real-time behavior in actual classroom situation or participation in science activities can help present a better understanding of the reality of expected outcome.

Studies have anticipated that participation in science-related activities helps promote interest in science which motivates STEM career choice [17, 18]. Science activities which are closely linked to the curriculum have been known to be more educationally effective as they deepen knowledge and understanding of the students along with the development of scientific concepts [19, 20]. Both structured (museum visits, science clubs/ competitions) and unstructured activities (socializing, fiddling with objects, reading fiction/nonfiction) stimulate interest among students at different levels [21] thereby emphasizing implementation of such programs. Moreover, practical experiences also contribute significantly in concept formation and perform inquiry-oriented discovery of scientific principles [22]. Science laboratories play an indispensable role in triggering curiosity, promotion of positive attitudes and cognitive growth of students which may further lead to increased interest and motivation towards science.

The current study was therefore designed in a way to understand students' participation in science activities and science laboratories, with an understanding of classroom behavior of students specifically in a science classroom. Hence, the primary research question for the study remains to understand the relationship of the above factors with STEM aspirations and also to understand the level of students' participation in different forms of science activities (In school, out of school, structured and unstructured). Thirdly, the status of science laboratories in terms of physical infrastructure, accessibility, and usability of laboratories by the students will be assessed.

METHODS

Participants and data collection

The study implements an explanatory mixed method type design [23] to gather information wherein questionnaire based items were used for STEM aspirations, participation in science activities, science classroom behavior and science laboratory participation. Questionnaire titled "Is Science me" has been used in the current study which has been previously used by the U.S. National Science Foundation as a part of a research project with the same name [3, 6]. The questionnaire explores science identity as a product of school, family, peer and self-related factors a few of which have been discussed in the current study. Most of the survey questions have been measured on two, three and four-point scale. Principal component methods and varimax rotation techniques have been used while the development of questionnaire to arrive at above mentioned multi-item factors. STE aspirations were measured on a continuous additive scale (4= Very interested and 1= not interested), participation in science activities (3= always, 1= never) and science classroom behavior (4= always, 1= never). Assessment of science laboratory environment was done based on the observations made by the investigator during the coursework, along with it interaction with the students based on the annotations made by the investigator was also carried out. This helped in understanding the problems and challenges faced with regard to the research questions of the study.

For data collection, necessary permission was obtained from the head of the school and students were oriented with study objectives and confidentiality of the information. The sample for the study was 150 ninth grade students in the age group of 14-16 years from two different government schools of Haryana state, who agreed to participate in the study. The schools were selected randomly and belonged to urban and rural backgrounds in order to have a comparative picture of the situation under both distinctive circumstances.

RESULT & DISCUSSIONS

Participation in science activities

Students' participation in science activities was assessed in a way to categorize and compare them among different categories of structured and unstructured activities, in school and out of school activities. Overall the data reflected 32% participation in the higher category and 28%, 40 % respectively for average and lower groups. Based on the responses of the students it was found that students engaged more with both unstructured and out of school activities.

Unstructured v/s Structured activities- For unstructured activities like spending time outside learning about nature, talk with friends and family about science, 55-60 % agreed upon to have been engaged in such activities. Boys were more inclined towards taking apart things such as electrical appliances to see how they work whereas girls agreed more with collecting stones, leaves, feathers or other nature related things. Structured activities like a visit to a science museum, fair, library was least popular among students. Only 10-12% of students agreed to have participated in such activities. Overall structured activities were less in practice as compared to unstructured activities.

It was observed that unstructured activities showed more participation as compared to structured ones. Moreover, the structured activities have been known to generate situational interest and unstructured towards individual interest [17]. Individual interest tends to have more permanence as compared to situational interest [23], which is not reflected upon by this study as students' participation with unstructured activities was more but still, their STE aspirations were not much on the higher side.

In school v/s Out of school activities- In school activities which are supposed to be a part of the curriculum showed the least percentage of participants with a meager 5% student participation. Students were found not to have been part of any science club or science program, science quiz was rarely organized by the school in the rural area whereas urban school students had exposure to science quiz which was arranged once or twice a year. Out of school activities which are performed by students usually when they are at home with their parents/ family such as using tools to build things, reading books on science fiction or visiting nature/ science related places, were enjoyed by the students predominantly. More than 60% of students agreed to have participated in a few of these activities regularly.

In-school activities also found to be least contributing as compared to out of school activities, therefore, more activities of such sort need to be organized so as to create curiosity and enjoyment of learning among students, which is essential for building interest [17]. Participation in science activities is highly related to the socioeconomic status of the individuals [25] therefore rural students were less inclined as compared to their urban counterparts.

Involvement of parents with students for participation in science activities was found to be much less and students mostly relied on their siblings or peers for guidance and motivation. The predominant reason for this can be most of the parents were uneducated or possessed a bare minimum qualification.

Participation in science laboratory

Students' participation in science laboratory was primarily assessed in terms of availability of infrastructure, accessibility, and usability of laboratory facilities by the students.

Physical infrastructure – Science laboratories visited were found to be highly deficit and under structured based on school science laboratory standards. For the rural school, in the name of science laboratory, a small dingy, multipurpose room was available with no proper ventilation and safety measures as recommended by CBSE (Central Board of Secondary Education) guidelines. The seating arrangement was highly unsatisfactory with space for no more than 10-15 students, whereas class strength for each section of school as around 40-45. In terms of materials and methods, outdated kits, chemicals existed and a few basic science models and charts were present. No laboratory attendant had been appointed and the laboratory was attended to and maintained solely by the science teacher. For the urban school, a separate laboratory with sufficient seating arrangement and ventilation was present but it was also not very well maintained. The lab was found to be surprisingly underprovided with apparatus and materials necessary for carrying out basic science experiments, few kits present were lying unused and were way past their date of expiration. A few of the apparatuses present such as microscopes were found to be in non-working condition, also no separate lab attendant was appointed and labs were being managed by the science teacher.

Accessibility and usability of laboratory facilities- Although separate periods/ lectures had been devoted in the timetable for science practical but the laboratories remained inaccessible to the students. Firstly, students had rarely visited science laboratory, around 62% of students agreed to have never visited as a science laboratory during their academic session, 24% agreed to have visited 2-3 times during the session but also most of the times the experience was not different from a theory class as mostly they were just studying from their textbooks rather than exploring concepts using the process of scientific inquiry. 14 % of students agreed to have been visiting laboratories 3-4 times a month and "observing" experiments, here also the major lacking was that the teacher would demonstrate the experiment to the students, and rarely a few of them would get a chance to actually perform, as their teachers said that materials were not enough to cater to each and every student. Practical record books were also not regularly prepared by the students and remain a formality which is usually completed by the students and also assessed by teachers towards the end of the academic session.

Science laboratories presented a very grim and dwindling situation which needs immediate attention, as the basic premise of science which is discovery and inquiry [22] are being disregarded. The most lacking point here is not just about the material, method or apparatus it is the lack of intention among teachers to present pursuit of scientific discovery. Students were found to state that teachers cited the use of laboratories to be burdensome and often overlooked science practical. Practical work has been associated with mixed response when it comes to a long-term engagement with science [26-27] reported negative relationship at the same time [28] and [29] associate scientific investigations positively with a future in science, but nonetheless positive outcomes of practical work in generating short-term engagement in science can't be ignored.

Science classroom behavior

Overall science classroom behavior reflected a trend wherein 22% and 46% of students depicted favorable and unfavorable classroom behavior. To delve a little deeper when asked that whether the students worked in a classroom for an extra credit a total of 71.5% agreed to have written assignments, and worked on classroom tests devotedly in order to gain extra credit. This percentage was contributed more by urban students and also girls reflected to have worked more dedicatedly for extra marks. In order to assess students' participation in science classroom, they were asked about how frequently they asked questions in a classroom, to which 8% agreed to have always asked questions, while a majority of them were less vocal about their doubts. Interestingly, on being asked whether they ever feel bored in a science classroom, to which 46% agreed to have felt boredom from time to time.

Science classroom behavior is an important component for the formation of science identity among students [3]. The current data presents some stark realities, where only a few (8%) have a voice in a classroom and around half of them feel bored, this challenges the connect which the students have with the teacher, curriculum (content) being taught and also the teaching methodology being used by the teachers. Teachers in these schools mostly resorted to the traditional passive methods of teaching, but the zeal of students and their want to work for extra credits (71.5%) reflects that they are ready to invite a change. The change which can bring out the best in them and make them relate to the subject/ content being understood in classroom situations.

STE aspirations- This study is in continuation with the work performed under an earlier study to identify the factors affecting science identity among secondary school students in India [9] wherein only 25% of the students presented a higher level of STE aspirations. The main contributing factors which have been identified previously were primarily teacher expectations and self-beliefs, parental attitude towards science and peer attitude towards science.

Based on the student responses a critical observation was made which reflected a lack of guidance and career orientation towards science related fields. Most of the

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student's related science with being a doctor or an engineer especially in rural area. The students were found unaware of other opportunities which are available in the field of science. Since to be a doctor or engineer needs a lot of hard work and financial support, therefore, most of the students were found to shy away from future participation in science.

Although the government of India facilitates education or meritorious or backward students with a large number of scholarship schemes to provide them with requisite financial support, the lack of awareness about such schemes underplays the career / future aspirations of students in science. Therefore, guidance and career counseling facilities should be recommended and initiated in all schools to help facilitate student participation in science.

Correlational Analysis

Pearson's coefficient of correlation was determined to understand the relationship between STE aspirations, participation in science activities and science classroom behavior.

Pearson's correlation coefficient	Science classroom behavior	Participation in science activities
	0.145*	0.352*

*Significant at .05 level of significance

As presented through analysis of the data participation in science activities presents a positive relationship (0.352) with STE aspirations, which is in accordance with Hofstein and Lunetta [22] where science activities participation has been found to be a significant contributor of a long-term association with science. Science activities are mostly related towards creating a situational interest which may not always ensure a long-term association with the field. Whereas a very low correlation was depicted with classroom behavior, which is mostly an achievement-oriented concept, therefore, a favorable classroom behavior might not always transcend towards a career interest in science.

CONCLUSION

In consonance with the results presented by the study, it can be reflected that the discrepancy associated with long term association of students with science is because of the inability of students to associate and value themselves with science. This value associated with science can be harnessed by engaging students with science activities and ensuring active participation in science laboratories, which requires sincere effort on the part of teachers, parents and school administration for providing experiential learning experiences as stated by the social cognitive career choice model. Science classroom behavior which is often used as a measure of students' interest in science is shown to be a false measure as it is an outcome of achievement motivation and at times is the result of the personality trait of the students. In relation to the science laboratory participation, lack of physical infrastructure and essentially lack of commitment among teachers towards inculcation of scientific inquiry among students does not allow students to associate themselves with the utility value of science. For this more laboratory periods can be included during the session, also stringent monitoring of teaching work should be done and recognition of good teaching practices should be revised significantly. Guidance and counseling programs should take an upstage during school sessions as students are often misled or unaware of the opportunities lying ahead.

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