A Study of Problem-Solving Abilities and Scientific Attitude among Secondary School Students.

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Abstract: The present descriptive survey explores the problem-solving abilities and scientific attitude among secondary school students. By random sampling 104 girl students and 108 boy students of IX class of two Government schools in Delhi state were selected. Problem-Solving Ability Test (L.N. Dubey) and Scientific Attitude Scale (Sukhwant Bajwa and Monica Mahajan) were employed as tools for data collection. It was found out that girl students had significantly higher problem-solving abilities and better scientific attitude than boy students. Problem-solving abilities & scientific attitudehad significantly positive correlation with each other. The study also had educational implications for different stakeholders.

Keywords: Problem-solving abilities, Scientific attitude, Secondary School Students.

*Introduction

Problem-solving plays an important role in the academic achievement and knowledge construction by the students (Kousar, 2011). Problem-solving is a process that is used to solve a problem that does not have an obvious solution (Polya, 1945). Problem-solving ability refers to the skills that support a student to arrive at a state of solution in which problem does not exist anymore (Mayer & Wittrock, 2006). Problem-solving ability is a crucial cognitive factor that is of paramount importance for the teachers (Gupta et al, 2015) to facilitate content learning. Also, enhancing the problem-solving abilities of the students is of great concern for educational psychology (Mayer & Wittrock, 2006). Problem-solving as a cognitive process and framework involve reasoning, logic, critical and creative thinking and decision making on the part of the students and that ultimately leads to learning. As an instructional method, problem-based learning motivates the students to learn (Marra et al, 2014). Unstructured problems, rather than structured problems, require the students to exercise greater cognitive skills (Hong, 1998). At a concrete level, well-structured problems support the students to comprehend well and apply problem-solving skills (Kusmiyati et al, 2019). At the abstract level, the unstructured problems, facilitate the students to associate their abstract knowledge with daily life situations as they learn to focus their thinking on new information (Hong & Kim, 2016). The problem-solving ability is greatly influenced by the cognitive styles of the students (Keefe, 1987). Cognitive style is the learning style of an individual that supports him/her to receive and process the information. As a process, the first aspect of the problem-solving involves the problem representation by the students in which the students differentiate between the unknown and known parts of a problem (İncebacak & Ersoy, 2016). During this, certain features of the problem under investigation may activate the problem-relevant knowledge in the memory of the students (Kintsch & Greeno, 1985 and Wang & Chiew, 2010). Since the problem-solving strategies are schema driven, there may be a match between the features of the problem and solution goal of the problem in the schema of the students and hence that particular schema may be activated **(Cheng et al, 2018).** So, by activating the schema associated with the prior knowledge and experience of the previously solved problem the problem-solving becomes easier (Chen, 2010; Gick, 1986; Hmelo-Silver, 2004, İncebacak & Ersoy 2016 and Kirschner et al, 2006). To activate the relevant schema

for problem-solving, appropriate instructional support and motivating learning environment are also necessary (Kirschner et al, 2006 and Van Merrienboer et al, 2003). The problem-solving ability on the part of expert problem-solvers requires the use of domain specific strategies by them and these domain-specific strategies are specific to the problem itself also (Bulu & Pedersen, 2010; Mayer, 1992; Wang et al, 2013 and She et al, 2012). Even the domain-specific knowledge supports solving ill-structured problems also (Voss et al, 1983).

Besides the problem-solving ability that facilitates concept learning another important learning characteristic amongst the students that influences their intellectual capacity is scientific attitude. Scientific attitude is an essential prerequisite to being an effective problem-solver (Gupta, 2015). Scientific attitude supports the students to free themselves from unverified assumptions, biases, false beliefs, superstition and popular opinion without any empirical basis (Klopfer, 1995). A student with a scientific attitude has open-mindedness, objectivity, rationality and readiness & desire for accurate knowledge and also, he/she shows confidence in the procedure for seeking knowledge (Jan & Gupta, 2014). A well-planned science education curriculum is successful enough to nurture scientific attitude amongst the students. The process approach of science, rather than the product approach of science inculcates scientific attitude amongst the students. Citing definition, principals and theory reflect the product nature of science while setting up apparatus, instruments to arrive at the conclusion, etc is the process approach of science. The modern world is the scientific world with economic prosperity, civic enlightenment and social development which requires the nations and societies to develop a spirit of scientific attitude amongst its people. Education, as a tool, can be effective enough in achieving this aim through science education whose chief objective is the development of scientific attitude amongst the students (Ksheerasagar & Kavyakishore, 2013). As per the Indian education system, schooling of the first ten years is common to all students which involve science teaching up to secondary school level. However, after secondary school level, there is a provision of stream specialization for the students at the senior secondary level that is science, business studies, humanities, and vocational streams are available for the students to opt. So, the first ten years are utilized to develop scientific attitude amongst the students irrespective of their choice of the stream at the senior secondary level.

So, how do the problem-solving abilities and scientific attitudediffer amongst girl and boy students at secondary school level and how do problem-solving abilities and scientific attitude correlate with each other motivated the investigator to conduct this study.

*** Literature Review**

In the research domain of problem-solving, the studies have reported that problem-solving had a significant effect on the academic achievement of secondary school students **(Gupta et al, 2015, Kumar & Singhal, 2014** and **Perveen, 2010)** that means the students having higher problem-solving skills had better academic achievement. The problem-solving abilities and gender do not interact to influence the academic achievement **(Gupta et al, 2015)** and also there is no interaction effect ofproblem-solving learning models and cognitive styles on the learning outcomes of secondary school students **(Kusmiyati et al, 2019).** Studies have reported that male students performed significantly better than female students in mathematical problem solving **(Gallagher et al, 2000)** but some study reported that there was no significant difference between the problem-solving skills of male and female students in physics problem -solving **(Harskamp et al, 2008).** The correlational studies have found that there exists a significantly positive correlation between the problem-solving and working memory of secondary school students **(Kalaimathi, 2015).** The structured problems support the better learning outcomes of high school students **(Kusmiyati et al, 2019).** Problem-solving instruction had significantly positive effect on the immediate and retaining effects in physical science at middle school level **(Cheng et al, 2018).** Scientific problem-solving

significantly improves the students' scientific knowledge, problem-solving and reasoning **(Cheng et al, 2018).** Problem-solving supports in the correction of the misunderstanding of concepts amongst the students and thus helps in developing self-confidence and responsibility amongst them **(Armagan et al 2009** and **Elvira et al, 2016).** In the research area pertaining to the scientific attitude, studies have reported a significant positive correlation between the scientific attitude and teaching effectiveness **(Siddiqui & Khan, 2018)** and academic achievement in science of secondary school students **(Ksheerasagar & Kavyakishore, 2013** and **Jampannanavar & Yadawad, 2018**) and higher secondary school students **(Singh et al, 2016).** With respect to the scientific attitude, no significant difference between boy and girl students at the higher secondary level have been reported **(Gupta, 2015** and **Siddiqui & Khan, 2018)** and secondary school level **(Chakraborty & Gogoi, 2014** and **Meenakshi & Vasimalairaja, 2016).** But some studies reported that girl students had significantly better scientific attitude than boy students at secondary school level **(Rao & Reddy, 2016).** With respect to school locality, secondary school students of the urban area had significantly better scientific attitude than secondary school students of rural area **(Chakraborty & Gogoi, 2014).** But some other study reported that in comparison to urban secondary school students, the rural secondary school students had a significantly positive correlation between the scientific attitude and academic achievement (**Jampannanavar & Yadawad, 2018).** As far as the school management was concerned, some studies reported no significant difference between the scientific attitude of Government secondary school students and private secondary school students **(Meenakshi, & Vasimalairaja, 2016)** but some other studies found that the Government secondary school students had significantly higher scientific attitude than private secondary school students **(Rao & Reddy, 2018).** It was also reported that at higher secondary level there exists a significant difference between the scientific attitude with reference to stream of study that is science and non-science streams. The students of science stream had significantly better scientific attitude than the students of the non-science stream **(Gupta, 2001).** A significant main effect of scientific attitude on academic achievement in science of secondary school students was also reported **(Ksheerasagar & Kavyakishore, 2013).** However, there was no interaction effect of scientific attitude and academic achievement motivation and scientific attitude and type of school (Government and private) on the academic achievement of secondary school students in science **(Ksheerasagar & Kavyakishore, 2013).**

***Research Questions**

The literature review revealed that with respect to problem-solving abilities and scientific attitude there are mixed findings as in the domain of problem-solving, some studies reported that male students outperformed female students in mathematical problem solving **(Gallagher et al, 2000)** but other study found that male and female students did not differ significantly in physics problem -solving **(Harskamp et al, 2008).** The studies conducted in the research area of scientific attitude found that boy and girl students do not differ significantly at the higher secondary level **(Gupta, 2015** and **Siddiqui & Khan, 2018)** and secondary school level **(Chakraborty & Gogoi, 2014** and **Meenakshi & Vasimalairaja, 2016).** However, some researchers reported that for scientific attitude at the secondary school level, there exists a significant difference in the favor of girl students **(Rao & Reddy, 2016).** Thus, there was no exclusive study that could support the investigator to frame the directional hypothesis to explore gender differences with respect to problem-solving abilities and scientific attitude. As far as correlational studies are concerned, the investigator could not come across any study that explored the correlation between these two variables under study that is problem-solving abilities and scientific attitude.

So, the above discussion facilitated the investigator to frame the following research questions:

* How do problem-solving abilities vary amongst the girl and boy secondary school students?
* How do girl and boy secondary school students differ from each other in scientific attitude?
* How are problem-solving abilities and scientific attitude co-related with each other?

*** Research Objectives**

Following research objectives wereformulated by the investigator to answer the above research questions:

- To study problem- solving abilities among girl and boy students at secondary school level.
- To study scientific attitude among girl and boy students at secondary school level.
- To study correlation between the problem-solving abilities and scientific attitude among secondary school students.

***Methodology**

In the present study, the descriptive survey research design was adopted. The investigator attempted to study the difference between problem-solving abilities and scientific method of girl and boy students, studying in class IX, of secondary schools of Delhi state. The relationships between problem-solving abilities and scientific attitude of these students were also studied.

***Sample**

One Government Girls Senior Secondary School and one Government Boys Senior Secondary School were randomly selected from Delhi Government schools for the study. The students of the selected sample were of class IX (age group 13+ years) and in Indian society, this age marks the beginning of the adolescent stage.

***Variables**

- **Independent variable:** The independent variable was gender in this study. This variable varied two levels namely girls and boys.
- **Dependent variable:** Problem-solving ability, scientific attitude, and academic achievement motivation were the dependent variable in the study.

***Tools**

For the present study, the following standardized tools were used for data collection:

- **Problem-Solving Ability Test by Dubey:** In this test, there are twenty (20) items. It can be administered on the students of the age group 11-25 years. The reliability of the test was 0.78 and 0.76 by the split-half method and the rational equivalence method respectively.
- **Scientific Attitude Scale by Bajwa and Mahajan:** this scale, there are forty-nine (49) statements of which twenty-one (21) are positive while rest twenty-eight (28) are negative. The scale measures five dimensions namely the rationality (9 statements), curiosity (6 statements), open-mindedness (11 statements), faith in the scientific method (10 statements) and aversion to superstition (13 statements). The reliability of the whole test was 0.970as determined by the test-retest method. The index of suitability ranged from 0.92 to 1 which shows that the content of this scale measures the traits which it intends to measure. The concurrent validity of the scale was also established. The scale can be administered on the students of classes IX-XII.

***Procedure**

As per the manual of the educational tests, the tests were administered on the selected sample. The scoring of responses was done as per instructions given in the manual. Then, skewness of the problem-solving abilities and scientific attitude scores of boy students and girl students were calculated and the skewness value for problem-solving scores was 0.31 and for scientific attitude scores it was -0.12 which shows that the selected sample was approximately symmetrical so the collected data can be subjected to parametric tests.

Results & Discussion

S.N.	Variables	Gender	N	Mean	S.D.	σ_d	D	t-value
1	Problem-solving abilities	Girls	104	15.2	2.27	1.95	6.66	**3.42**#
		Boys	108	8.54	3.60			
2	Scientific attitude	Girls	104	156.15	16.39	2.06	6.52	**3.15**#
		Boys	108	149.63	19.66			

.01 level of significance * .05 level of significance

($\sigma_{d=}$ standard error of difference between the means; D= the difference between the two independent means).

Table 1: t-test for the problem-solving abilities and scientific attitude of girl and boy students at the secondary school level

*The table 1 shows that for problem-solving abilities, the obtained t value 3.42 is significant at .05 and .01 levels of significance in the favor of girl students at the secondary school level. This finding differs from the research work by Gallagher et al (2000) who reported that male students significantly performed better than female students in problem-solving and Harskamp et al (2008) whose research work found no significant difference between male and female students in problem-solving. The plausible reason for the above finding may be due to the reason that in girl students' school, the teaching of content might have been supported through well-structured and ill-structured problems because mere teaching alone cannot nurture problem-solving abilities amongst the students. Teaching concepts with the help of concrete examples and subsequently heading towards abstract examples may also support the students in developing problem-solving abilities.

*For scientific attitude, the obtained t value 3.15 is significant at .05 and .01 levels of significance in the favor of girl students at the secondary school level. The study by Rao & Reddy (2016) supports this finding of the study. However, this finding does not support the research work by Gupta (2015), Siddiqui & Khan (2018), Chakraborty & Gogoi(2014) and Meenakshi & Vasimalairaja (2016) where no significant difference between the two genders at secondary school level with respect to scientific attitude was reported. So, this finding of the present study is antagonistic to some studies but in support of some other study. The plausible reason for this finding in the favor of girl students maybe because of the better academic infrastructure like science laboratory in girl schools and hence their better exposure of science practicals, experiments and activities in a science laboratory and science classroom. Also, more focus on the process approach rather than the product approach of science by teachers in girl schools and hence motivating the students to frame the questions pertaining to the content taught in the class might also have supported the girl students to have a better scientific attitude.

S.N.	Variables	r value	t value
1	Problem-solving abilities and Scientific attitude	0.48	7.93#

.01 level of significance * .05 level of significance

Table 2: Karl Pearson coefficient of correlation (r) and concerned t-values between scores of two dependent variables

*The table 2 shows that for correlation between the problem-solving abilities and scientific attitude, the obtained value of Karl Pearson's Product Moment Coefficient of Correlation (r) is 0.48 and the concerned t-value is 7.93 which is significant at 0.01 level of significance. The plausible reason for this finding may be that the scientific attitude enriches the cognitive domains of students to probe and think the in-depth, reason for the happenings around them and thus developing a habit of not accepting the things as such and unquestioned. On the other side, problem-solving being a cognitive process gets enriched through the scientific method which itself is a logical and reasoning-based thinking process so, both that is problem-solving abilities and scientific hence a positive co-relation result between them.

***Educational Implications**

The present study has the following educational implications for the students, teachers, parents and school administrators:

***Educational implications for students:** The students need to explore the problem given with logic and reasoning. They may question the teachers about the topic, issue or content being deliberated in the class. They need to work with energy, experiment and discover with curiosity as such habits develop scientific attitude among them. The participation of the students in the learning process by questioning, cross-questioning, self-questioning may develop critical thinking among them that can support them in developing problem-solving abilities.

*** Educational implications for teachers:** The teachers need to adopt a student-friendly approach as it may intrinsically motivate the students to attempt the task. The teachers can discuss and dwell deep with the students while exploring a problem. The teachers should explain the objectives, of the task in hand, to the students as it may support the students to comprehend the phenomena well and in the long run, such practices may develop self-confidence among them. The teachers may organize group discussions in the classroom on certain themes, issues where the students can learn to debate, share, assert and exchange their views. Content teaching should be followed by sufficient questioning by the teachers. When answered by a student, then the teacher should ask the rest of the class to verify the correctness of the answer or response that is the answers, responses should not be accepted as such without verification. Such practices develop reasoning among students. In the classroom, the teaching of science subject by process approach rather than product approach may facilitate the teachers in developing scientific attitude among the students.

*** Educational implications for parents:** Due care, concern, advice and friendly attitude on the part of the parents may support the students to think with logic and emotions both. A healthy family environment may lay sound educational foundations for the students. The parents being the first teacher of the child, may support him/her to think with reason and avoid accepting the things as such that is without reasoning.

*** Educational implications for School administrators:** The school administrators need to ensure a suitable emotional, physical and intellectual environment so that students may work with zeal. The school laboratories of all subjects should be well equipped with teaching-learning material so that students do not face any obstruction in exploring some content. The teachers may be relaxed from assigning them administrative works as such practices exhaust the teachers and their potentials are not utilized fullest.

***Conclusion**

In this global scenario, where industrial and technological changes are taking place exponentially, so to cope with this challenging society the education system needs to nurture problem-solving abilities amongst the students. Problem-solving is the highest form of learning. A scientific attitude develops objectivity and open-mindedness amongst the students

and it is an indispensable skill that is to be developed exclusively through science teaching. So, there is a dire need to view problem-solving abilities and scientific attitude as inborn personality traits of students. The researches and related literature in these knowledge domains are substantially enriching the professionals. Adopting the research outlook, the present study was conducted and it was found that girl students at secondary school level had significantly better problem-solving abilities and scientific attitude than boy students. Problem-solving abilities and scientific attitudewere mutually positively correlated with each other.

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