AWARENESS OF SOCIO-SCIENTIFIC ISSUES AMONG THE HIGHER-SECONDARY STUDENTS

Sunita Singh
Associate Professor
Faculty of Education
BHU, Varanasi

Sharda Singh
Science Teacher
Upper Primary School
Chiraigaon Block, Varanasi

Science and society are interdependent and all aspects of science are inseparable from the society from which they arise. Today, society is continuously confronting numerous issues concerned with health and environment like cloning, ozone depletion, etc. These issues emerged from the interactions of science and society hence it is important to create awareness towards socio-scientific issues among students. The main aim of present paper is to study the awareness of socio-scientific issues among the higher secondary students. For this purposes researchers used self-developed 'Awareness of socio scientific issues' tool. This tool was administered on 654 higher secondary school students. It was found that majority of students are not aware of socio-scientific issues. In addition, it was also found that awareness of socio scientific issues among students is influenced by gender, board, academic discipline whereas it is not influenced by locality of students. Findings of research urge the need to develop suitable syllabus, textbook and teaching strategies so that it increases the awareness among students towards socio scientific issues.

Keywords: Awareness, Socio-scientific issues, Higher-secondary student

Introduction

The world around us has been increasingly shaped by science and technology. It also acts as a tool which can remove all those evils and constraints which may hamper the progress of the nation. It continues to advance day by day on a global basis, it is, therefore, essential for people to be prepared for these changes which are only possible when they become scientifically literate. Viewing the presence and importance of science in all walks of life and to prepare students to cope these changes educators, policymakers and reformers advocated science education for every child, at least up to a certain level of schooling. As a result of which science has become compulsory up to a certain level of school education in most of the countries. In India, Education Commission (1964–66) also recommended for compulsory science education up to Class X which was implemented in 1975, since then Science became compulsory for all students up to Class X, as a part of general education. The basic aim of general science education was not just limited to producing scientists but to create a scientifically literate citizenry able to use scientific knowledge in dealing with socio-scientific issues.

Science and society are interdependent and all aspects of science are inseparable from the society from which they arise but the socio-scientific issues exhibit certain unique characteristics, societal interests, effects and consequents (Sadler, 2002; Sadler and Zeidler, 2004).

Today, society is continuously confronting numerous issues concerned with health and

environment like cloning, gene therapy, stem cells, genome projects, ozone depletion, global warming, climate change, alternative fuels, nuclear energy, etc. (Kolsto, 2006; Sadler, 2003, 2004b; These issues emerged from the interactions of science and society and hence termed as socio-scientific issues (Eggert and Bogeholz, 2009; Kolsto, 2001; Sadler, 2004; Zeidler, et al. 2002). So while dealing with issues one confronts two kinds of questions, the first question is framed from the perspectives of ethical, personal or social scenario while the second question involves the scientific aspect of the issue (Kolsto, 2006) The use of the term socio-scientific issues (SSI) in the literature is found as far back as the 1980s (Zeidler, 2014).

As defined by Sadler (2004b), socio-scientific issues are societal dilemmas with conceptual, procedural, or technological links to science. Eggert and Bogeholz (2009) posited "socio-scientific issues are complex in nature and typically do not have a clear-cut solution. While they have their basis in science, they cannot be solved by referring solely to scientific knowledge. Rather, they involve various societal aspects and have to be resolved through the integration of different, often competing, perspectives" (p. 231)

Barrett and Nieswandt (2010) posited that socio-scientific issues are "complex problems— that involve— scientific data as well as ethical considerations". Zeidler (2003) explained the meaning of socio-scientific issues (SSI) as issues that involve the deliberate use of scientific topics that require students to engage in dialogue, discussion, and debate. They are usually controversial in nature but have the added element of requiring a degree of moral reasoning or the evaluation of ethical concerns in the process of arriving at decisions regarding possible resolution of those issues. The intent is that such issues are personally meaningful and engaging to students, require the use of evidence-based reasoning, and provide a context for understanding scientific information (cited in Zeidler and Nicholas, 2009).

The recent NCF-2005 emphasised the active participation of the learner in the construction of their knowledge. It suggested the basic criteria of validity of a science curriculum. Content validity and process validity were related to the components of scientific literacy, whereas environmental validity was linked to socio-scientific issues.

The national focus group on teaching of science (NCERT, 2006) suggested that science curriculum up to Class X should be oriented more towards developing awareness among the learners about the interface of science, technology and society, sensitising them, especially to the issues of environment and health, and enabling them to acquire practical knowledge and skills to enter the world of work (p. 11).

It further expressed that in the contemporary society numerous socio scientific issues (with science as well as social, political and ethical links) emerge, so curriculum up to Class X should be designed to develop awareness among students about these issues. Hence, it described the application of scientific knowledge as one of the general aims of science education. It stated that science education should enable the learner to know the facts and principles of science and its applications, consistent with the stage of cognitive development (p. 11).

In the light of the above discussion, it has become clear that since very long, our

educational policies and reforms documents acknowledged the importance and need of the scientific literacy and connecting science to the everyday life so that a scientifically literate citizenry, able to make appropriate decision on socio-scientific issues could emerge and contribute to the development of the country.

In India and abroad, various researches have been conducted to explore scientific literacy and socio scientific issues in the last few decades. Laugksch and Spargo, 1996; Raza, et al., 2000; Mythili, 2002; Shwartz, et al., 2006 and Paula, 2007 have assessed scientific literacy among participants. Yates, 1998; and Foster and Shiel-Rolle, 2011 have studied the factors influencing scientific literacy. Nwagbo, 2006; Carlson, 2008; Webb, 2009; Mahatoo, 2012 and Nikam, 2013 have made strategies to improve scientific literacy. Awareness of socio-scientific issues was assessed by Chang Rundgren, 2010. Sadler, et al. (2006) and Malhotra (2017) investigated the teachers' perceptions on the teaching socio-scientific issues. They found that teachers' belief, school leadership and assessment system are the most influential factors for socio-scientific issues. Kolsto (2006), Pinzino (2012) and Rundgren, et al. (2016) have studied students' argumentation and decision making to authentic socio-scientific issues.

Reviews related to socio-scientific issues rendered us essential information like students practices (reasoning, argumentation and decision making) in the context of socio-scientific issues. Some researchers explored how students negotiate information provided regarding socio-scientific issues and some explored the role of teachers, teaching models in enhancing the skills required to deal with socio-scientific issues. But the researcher has not found any relevant study that assessed the awareness of socio-scientific issues in higher secondary students. As higher secondary students have completed the general science education, their awareness of socio-scientific issues could provide useful information. In the absence of comprehensive information it is hard to say whether the objective of making them aware of socio-scientific issues has yet achieved or not. Thus a research gap was perceived and, therefore, it was imperative to undertake the study that could provide information about the current status of awareness of socio-scientific issues in students. Hence, the researcher selected the problem for the detailed and extensive study.

Research Questions

What is the level of awareness of socio-scientific issues among the higher secondary students?

Statement of the Problem

Awareness of socio-scientific issues among the higher secondary students.

Objectives

1. To study the awareness of socio-scientific issues among the higher secondary students.

(a) To compare the awareness of socio-scientific issues among the higher secondary students on the basis of

(i) Gender (male and female)

(ii) Locality (rural and urban)

(iii) Board (Central Board of Secondary Education (CBSE) and Uttar Pradesh Madyamik Shiksha Parishad (UPMSP)

(iv) Academic discipline (science and non-science)

Hypotheses of the Study: The null hypotheses tested at 0.05 level of significance as given below:

H01: There is no significant difference in the awareness of socio-scientific issues of male and female higher secondary students.

H02: There is no significant difference in the awareness of socio-scientific issues of higher secondary students on the basis of rural and urban locality.

H03: There is no significant difference in the awareness of socio-scientific issues of higher secondary students on the basis of enrolment in CBSE and UPMSP.

H04: There is no significant difference in the awareness of socio-scientific issues of higher secondary students on the basis of science and non-science discipline.

Operational Definition of Key Terms

1. *Awareness of Socio-scientific Issues*

In the present study the awareness has been defined as the awareness of scientific and social aspects of the socio-scientific issues. It is represented by the scores obtained by higher-secondary students after filling the awareness tool for socio-scientific issues Tool for Awareness of Socio-scientific Issues (TASSI).

2. *Higher Secondary Students*

In the present study higher secondary students have been defined as all those students who were enrolled in Classes XI and XII of CBSE and UPMSP schools in Varanasi.

Methodology

The present study was a descriptive study with cross-sectional survey design. All the higher secondary students of Varanasi enrolled in various schools affiliated to CBSE and UPMSP constituted the population of the study. As the population of the study was heterogeneous with respect to demographic and academic factors, stratified random sampling technique was used to draw the sample for the study. The sample consisted of 654 higher secondary students which were drawn from the strata constituted by the board, gender and academic discipline. The total respondents were 700 in number, of which the response sheets of 46 were incomplete and hence rejected. TASSI tool was used by the researcher to collect the data of awareness of socio-scientific issues among higher-secondary students. This tool consisted of 40 multiple choice questions related to socio-scientific issues (SSI).This tool includes two domains of SSI, i.e., health and environment. Health domain included items related to diseases, causes of diseases, cure of diseases and medical technologies. Saving environment, pollutions, wildlife and environmental laws/plans/agreements are the sub-domain of environment. The reliability of the tool was 0.711. The tool had face validity and content validity. Percentile norms were established for this tool.

Delimitations

1. The population was confined to Varanasi city.
2. The sample was derived from the schools affiliated to CBSE and UPMSP only.

Result and Discussion

Data collected through TASSI was analysed by using Data Analysis Tool Pack of MS Excel software. Descriptive analysis was done by using percentage, and independent samples t-test was employed for inferential analysis. Objective wise analysis has been done. One of the primary objectives of the present study was to study the awareness of socio-scientific issues among higher secondary students. It was measured by using TASSI. For being aware of socio-scientific issues, the higher secondary students needed to answer 24 or more questions correctly, or else they were declared as not aware of socio-scientific issues. The table shows the distribution of socio-scientific issues among the higher secondary students according to their marks obtained in TASSI.

Table 1

Awareness of socio-scientific issues among higher secondary students

Marks obtained	Number of students	Percentage	Total
>24	247	37.77%	654
<24	407	62.23%	

The above table reveals that majority of higher secondary students are not aware of socio-scientific issues as only 37.8 per cent of students have correctly attempted 24 or more questions on TASSI. Chang Rundgren (2010) investigated the awareness of three socio-scientific issues regarding certain variables and Yoonjeong, et al. (2016) also investigated elementary school students' awareness about socio-scientific issues and solutions about environmental topics but they did not attempt to assess the overall awareness among respondents. The present study is supported by Dawson (2015) who found that only one in three students (156, 35%) were able to provide a correct or partially correct response about the socio-scientific issue, greenhouse effect. To the best of the researcher's knowledge, no other study was conducted to assess the awareness of socio-scientific issues, so comparison is not possible. However, many factors could be asserted for the low rate of awareness of socio-scientific issues in higher secondary students. One of the basic constraints is prevailing examination system based on rote learning (NCERT, 2005). The other constraint is that the textbooks are overloaded with information. Though, textbooks are primary instruments for universalisation of good science education and instrument to realise the basic curricular objectives (NCERT 2005), but the upper primary textbooks of NCERT have superficially discussed the socio-scientific issues, more than that, their impact on society are also not discussed properly (Singh and Singh, 2018). So there is not enough scope for wider and participative discussions on socio-scientific issues. It is also hard for teachers to cover a large content based syllabus along with relating the scientific knowledge to the everyday life in limited time. Therefore, about 62 per cent of the students are not aware of socio-scientific issues.

The second objective of the present study is to compare the awareness of socio-scientific issues among the higher secondary students on the basis of gender (male and female), locality (rural and urban), board (Central Board of Secondary Education (CBSE) and Uttar Pradesh Madyamik Shiksha Parishad (UPMSP) and academic discipline (science and non-science)

Gender and Awareness of Socio-scientific Issues

Table 2

Summary of t-test regarding awareness of SSI of male and female higher secondary students

Particulars	Male	Female	α	df	Critical t value	Calculated t value
Mean	21.542	22.369	0.05	652	1.963	2.046
Variance	29.778	23.624				
Observations	315	339				

Significant at the level of significance P←0.05

Table 2 revealed that the table value of t for df = 652 is t0.05 = 1.96. The computed t-value for gender was 2.046, which was found significant at 0.05 level of significance for the degree of freedom 652. Hence, the null hypothesis 1, i.e., "There is no significant difference in the awareness of socio-scientific issues of male and female higher-secondary students" was not accepted. From the result, it can be said that in the current study there exists a significant gender difference in the awareness of socio-scientific issues of male and female higher secondary students. It means that female students performed better than male students on TASSI and hence, female students are more aware of socio-scientific issues than male students.

Although there have been many studies (Kara, 2012; Chang Rundgren, 2010 and Rizal, et al. 2017) that show no significant gender difference in socio-scientific issues but the findings of the present study revealed the significant gender difference in terms of awareness about socio-scientific issues.

Likewise, the present investigation Ekborg and Ottander (2010) in their study revealed a significant difference between how girls and boys judge the socio-scientific issues. Sadler and Zeidler (2003) concluded that besides scientific knowledge, other factors such as affective dimensions influence the argumentation in socio-scientific issues. Watts (2000) also argued that various factors like disappointment, disaffection, distaste, aversion as well as challenge, enjoyment, pleasure, and fulfillment influence the appreciation and learning of science. Reddy (2017) found that girls prefer biology while boys are interested in physics and chemistry. Kahle, et al. (1993) found that Australian teachers responded that girls performed better than boys in biological science. He also found that "boys, on average, were more interested in science associated with matter and energy (including electricity), whereas girls were more interested in science associated with plants and animals". Findings of Fonseca, et al. (2011) also showed that girls are always better than boys for the Identifying Scientific Issues competency (ISI). Likewise, Rundgren, et al. (2016) also found that female students seemed to ascribe more weight to health risks in their argumentation than male students. Hughes (2000) also found that female students enjoy socio-scientific context while male students reject it.

Locality and Awareness of Socio-scientific Issues

The difference in the people dwells in rural or urban area is not just limited to their

localities but the rural-urban differences are also reflected in various aspects of learning, aspiration and achievement of students (McCracken, 1991; OECD, 2013c; and Sharma, 2007). NCERT (2006) also showed concern on rural-urban difference, it stated there exist a huge gap in education in general and science education in particular between the rural and urban students (p. 29). There are various explanations to these differences. Sharma (2007) differentiates urban and rural areas explaining that socio-economic inequalities separate the two. McCracken (1991), and OECD (2013c) found significant differences in the students of urban and rural schools. NCERT (2006) considers poor infrastructure, inadequate support systems, lack of access to information and resources in rural areas are responsible for these differences. In the current study the schools selected for data collection were located in urban areas but the students enrolled there were from urban as well as rural backgrounds. Therefore, the researcher compared the students of rural and urban backgrounds for awareness of socio-scientific issues.

It is evident from Table 3 that the table value of t for df = 652 is t0.05 = 1.96. The computed t-value for gender was 1.575, which was found to be non significant at 0.05 level of significance for the degree of freedom 652. That is why, the null hypothesis 2, i.e., "There is no significant difference in the awareness of socio-scientific issues of higher secondary students on the basis of rural and urban locality" was accepted. It is revealed from the above result that students' performance on TASSI was equivalent, so locality background doesn't influence the socio-scientific issues.

In this study, the students with rural background were enrolled in urban schools so the constraints that limit the performance of students due to rural schools were not there. Rural students help their parents in farming, graze animals, they commonly identify and use a variety of plants as sources of food, medicines, fuel wood, dyes and building materials, they notice changes in season, so they have rich interactive experience of natural world (NCERT, 2006). Most science educators consider that students' knowledge and experience is vital for science learning (Duschl, et al. 2007). Nowadays science syllabus and textbooks also strive to link the students' life at school with outside world according to the recommendation of National Curriculum Framework (NCF, 2005). Textbooks also attempt to provide opportunities for contemplation and wondering, discussion in small groups and activities requiring hands-on experience (NCERT, Science Textbook). So the students, regardless of their rural background, are equally aware of socio-scientific issues.

Table 3

Summary of t-test regarding awareness of SSI of rural and urban higher secondary students

Particulars	Rural	Urban	A	Df	Critical t-value	Calculated t-value
Mean	21.413	22.090	0.05	652	1.963	1.575
Variance	27.833	27.920				
Observations	235	419				

Board and Awareness of Socio-Scientific Issues

The following table showed that the table value of t for df = 652 is t0.05 = 1.96. The computed t-value for board was 4.579, which was found to be significant at 0.05 level of significance for the degree of freedom 652. Hence, the null hypothesis 3, i.e."There is no significant difference in the awareness of socio-scientific issues of higher secondary students on the basis of enrolment in CBSE and UPMSP" was not accepted.

CBSE schools. According to Thareja (2015), CBSE is extremely focused on Science and Mathematics with a lot of attention paid to the application of knowledge. CBSE approves both Hindi and English as the medium of instruction so the students become competent in both the languages and they become able to apprehend information regarding socio-scientific issues from variety of sources. So the higher secondary students of CBSE were found more aware of socio-scientific issues than their counterpart from UPMSP.

Table 4

Summary of t-test regarding awareness of SSI of CBSE and UPMSP higher secondary students

Particulars	CBSE	UPMSP	A	Df	Critical t value	Calculated t value
Mean	22.710	20.993	0.05	652	1.963	4.579
Variance	33.580	10.339				
Observations	352	302				

The result indicates that in the present study, there is a significant difference in the awareness of higher secondary students of CBSE and UPMSP. The students of CBSE performed better than students of UPMSP on TASSI and, therefore, they are more aware of socio-scientific issues.

A report on quality in school education found that facilities like online learning, use of Information, Technology and Communication (ICT) and multimedia are available to some extent in CBSE schools. So, CBSE schools are technologically advanced in comparison to UPMSP schools. Also, community participation in school activities is more common in

Subject and Awareness of Socio-scientific Issues

The aim of general science education for ten years for all students is to expose them to fundamental concepts of science so they could become scientifically literate (NCERT, 2005). Curriculum up to this stage is also set in a way to develop awareness among the students about the relationship of science, technology and society and sensitising them about the socio-scientific issues related to environment and health.

In the present study, the students who opted science subject combination at higher secondary stage have been considered as science students and those students who did not opt science (but opted arts or commerce) have been considered as non science students.

Table 5

Summary of t-Test Regarding Awareness of SSI of Science and Non-science Higher Secondary Students

Particulars	Science	Non- Science	A	df	Critical t value	Calculated t value
Mean	22.825	21.601	0.05	652	1.963	3.498
Variance	27.070	10.362				
Observations	360	294				

From Table 5 it can be seen that the table value of t for df = 652 is t0.05 = 1.96. The computed t-value for board was 3.498, which was found to be significant at 0.05 level of significance, for the degree of freedom 652. Therefore, the null hypothesis 4, ie,. "There is no significant difference in the awareness of socio-scientific issues of higher secondary students on the basis of science and non-science subjects" was not accepted.

From the above result, it can be said in the present study that there is a significant difference in the awareness of higher secondary students of science and non-science subject. The science students performed better than the non-science students on TASSI and therefore, they are more aware of socio-scientific issues. Similar to the results of current investigation, Zeidler and Schafer (1984) found that science students performed better than non-science students in moral reasoning about an environmental issue. They also substantiate the link between content knowledge and reasoning about environmental issues. Ratcliffe (1999) also found that science experience attained through science education develops evidence evaluation skills in socio-scientific issues in science students. She concluded that students with more experience of formal science education perform better than the science students with relatively less experience of formal science education. Yang (2004) found that students showing ambiguity on their thoughts about a SSI due to their insufficient information. Kolsto, et al. (2006) also found results similar to Yang (2004) with science education students. Sadler and Zeidler (2004) compared the content knowledge and informal reasoning about genetic engineering issues of two groups of undergraduate college students from natural science and non-natural science and found that the students from natural science performed better. They also found that content knowledge influence the variations in informal reasoning quality about socio-scientific issues. Similarly, Lin (2014) also found that science students performed significantly better than non-science students in critical thinking performance about a socio-scientific issue. Science students have more experience that turns into better science content knowledge. As the science students have relatively more exposure to content knowledge and scientific information, therefore, they are supposed to be more aware of socio-scientific issues than the non-science students. Thus, the average performance of the science students on TASSI was found significantly better than the non-science students.

Findings

- On the basis of the above result the researcher derived that majority of students are not aware of socio-scientific issues.
- Awareness of socio-scientific issues among higher secondary students is influenced by gender, board, academic discipline, whereas it is not influenced by locality of students. As in the present study majority of socio-scientific issues have origin from biological sciences, in which female students are found to be more interested than male students, that is why female students outperformed male students in awareness of socio-scientific issues.

Educational Implications

1. The study provides the empirical data of the awareness of socio-scientific issues in the students that can be used by policy makers to make strategies to increase the awareness of socio-scientific issues.
2. Findings of the study provide the information of the factors that influence the socio-scientific issues. Teachers can use this information to provide appropriate opportunities to enhance awareness among students.
3. Policy makers can also use this information to develop suitable syllabus, textbooks, content and teaching strategies.

References

Barrett, S. E. and Martina, N. 2010 . Teaching about ethics through socio-scientific issues in Physics and chemistry teacher candidates beliefs. *Journal of Research in Science Teaching*, Vol. 47, No. 4, pp. 380-401.

Carlson, J.L. 2008. Effect of Theme-based, Guided Inquiry Instruction on Science Literacy in Ecology. Thesis. Michigan Technological University. Retrieved 31 Aug 2015 from,http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.698.874&rep=rep1&type=pdf

Chang Rundgren, S.N. 2010. How does Background Affect Attitudes to Socio-scientific Issues in Taiwan?. *Public Understanding of Science*. Vol. 20, No. 6. pp. 722–732. doi:10.1177/0963662509359998

Dawson, V. 2015. Western Australian High School Students' Understandings about the Socioscientific Issue of Climate Change. *International Journal of Science Education*. Vol. 37, No. 7. pp. 1024–1043. DOI:10.1080/09500693.2015.1015181.

Duschl, R. A., Schweingruber, H. A., and Shouse, A. E. (Eds.). 2007. *Taking Science to School: Learning and Teaching Science in Grades K-8.* National Academies Press. Washington, DC.

Eggert, S. and Bogeholz, S. 2009. Students' Use of Decision-making Strategies with Regard to Socioscientific Issues: An Application of the Rasch Partial Credit Model. *Science Education.* Vol. 94. pp. 230–258.

Ekborg, M., and Ottander, C. 2010. Working with Socio-scientific issues. Students' and Teachers' Experiences. Paper Presented at the XIV Symposium of the International Organisation for Science and Technology Education (IOSTE). Retrieved June, 2014 from http://dspace.mah.se/handle/2043/13094

Fonseca, J. Valente, M. O. and Conboy, J. 2011. Student Characteristics and PISA Science Performance: Portugal in Cross-national Comparison. *Science Direct.* pp. 322–329.

Foster, J.S., and N. Shiel-Rolle. 2011. Building Scientific Literacy through Summer Science Camps: A Strategy for Design, Implementation and Assessment. *Science Education International.* Vol. 22, No. 2. pp. 85–98.

Government of India. 1953. Report of the Secondary Education Commission 1952–53. Ministry of Education.

Government of India. 1966. Education and National Development: Report of the Education Commission 1964–66. Ministry of Education.

Government of India. 1968. National Policy on Education. 1968. Ministry of Human Resource and Development. Retrieved, July 15, 2014, from http://mhrd.gov.in/sites/upload_files/mhrd/files/document-reports/NPE-1968.pdf

Hughes, G. 2000. Marginalisation of Socio-scientific material in Science–Technology– Society Science Curricula: Some Implications for Gender Inclusivity and Curriculum Reform. *Journal of Research in Science Teaching.* Vol. 37, No. 5. pp. 426–40.

Kahle, J. B., Parker, L. H., Rennie, L. J. and Riley, D. 1993. Gender Differences in Science Education: Building a Model. *Educational Psychologist.* Vol. 28, No. 4. pp. 379–404.

Kara, Y. 2012. Pre-service Biology Teachers' Perceptions on the Instruction of Socio-scientific Issues in the Curriculum. *European Journal of Teacher Education.* Vol. 35, No. 1. pp. 111–129.

Kolsto, S. D. 2001. Scientific literacy for citizenship: Tools for dealing with the science dimension of controversial scioscientific issues. *Science Education*. Vol. 85, No. 3, pp. 291-310.

Kolsto, S. D. 2006. Patterns in Students' Argumentation Confronted with a Risk-focused Socio-Scientific Issue. *International Journal of Science Education.* Vol. 28, No. 14. pp. 1689–1716.

Kolsto, S. D., Bungum, B. Arnesen, E., Isnes, A., Kristensen,. T., Mathiassen, K., Mestad, I. Quale, A., Sissel, A. Tonning, V. and Ulvik, M. 2006. Science Students' Critical Examination of Scientific Information Related to Socioscientific Issues. *Science Education.* Vol. 90, No. 4. pp. 632–655.

Laugksch, R. C., and Spargo, P. E. 1996. Construction of a Paper and Pencil Test of Basic Scientific Literacy Based on Selected Literacy Goals Recommended by the American Association for the Advancement of Science. *Public Understanding of Science.* Vol. 5, No. 4. pp. 331–359.

Lin, S. S. 2014. Science and Non-science Undergraduate Students' Critical Thinking and Argumentation Performance in Reading a Science News Report. *International Journal of Science and Mathematics Education.* Vol. 12, No. 5. pp. 1023–1046.

Mahatoo, J. 2012. Scientific Literacy and Nature of Science as it Impacts on Students Achievement in South Trinidad. Thesis. The University of the West Indies Retrieved, 20 September 2016 from, http://uwispace.sta.uwi.edu/dspace/bitstream/handle/2139/12709/Judy%20Mahatoo.pdf?sequence=1

Malhotra V. 2017. Teachers' Perspective on Teaching of Socio-scientific Issues in India-Science Classroom (thesis). The University of Leeds. Retrieved from etheses.whiterose.ac.uk/id/eprint/15428 on 15 May, 2018

McCracken, J. D. 1991. Differences Between Rural and Urban Schools, Student Characteristics, and Student Aspirations in Ohio. *Journal of Research in Rural Education.* Vol. 7, No. 2. pp. 29–40.

Mythili, R. 2002. Preparedness for Multicultural Science Teaching and Level of Scientific Literacy among Student Teachers and Teachers of Science. Thesis. University of Madras. Chennai.

NCERT. 1975. The Curriculum for the Ten-Year School. New Delhi.

NCERT. 1988. National Curriculum for Elementary and Secondary Education — A Framework (revised version). NCERT, New Delhi.

NCERT. 2000. National Curriculum for School Education. NCERT, New Delhi.

NCERT. 2005. National Curriculum Framework-2005. NCERT, New Delhi.

NCERT. 2006. National Focus Group on Teaching of Science. NCERT, New Delhi.

NCERT. 2012. 'Science' Class VIII Science textbook, NCERT, New Delhi.

Nikam, P. S. 2013. Development of Teaching Strategies for Enhancing Scientific Literacy and Scientific Process Skills in Physics, Chemistry and Biology among Student Teachers. Thesis, Shivaji University, Kolhapur.

Nwagbo, C. 2006. Effects of Two Teaching Methods on the Achievement in and Attitude to Biology of Students of Different Levels of Scientific Literacy. *International Journal of Educational Research.* Vol. 45. pp. 216–229.

OECD. 2013c. What Makes Urban Schools Different?. OECD Publishing.

Paula, S. F. 2007. Scientific Literacy Among the Teachers and Students at the Higher Secondary Stage in Relation to Certain Selected Variables. Thesis. Bharathidasan University.

Pinzino, D.W. 2012. Socio-scientific Issues: A Path Towards Advanced Scientific Literacy and Improved Conceptual Understanding of Socially Controversial Scientific Theories. Doctoral Thesis, University of Florida Retrieved, 20 September 2014 from, http://scholarcommons.usf.edu/cgi/viewcontent.cgi?article=5583&context=etd

Ratcliffe, M. 1999. Evaluation of Abilities in Interpreting Media Reports of Scientific Research. *International Journal of Science Education.* Vol. 21, No. 10. pp. 1085–1099.

Raza, G., Surjit Singh and Bharvi Dutt. 2000. 'Public Understanding of Science in Complex Cultural Structures'. *Journal of Scientific and Industrial Research.* Vol. 59. pp. 460–470.

Reddy, L. 2017. Gender Differences in Attitudes to Learning Science in Grade 7. *African Journal of Research in Mathematics, Science and Technology Education.* Vol. 21, No. 1. pp. 26–36.

Rizal, H. P., P. Siahaan, and G. Yuliani. 2017. Implementation of Socio-scientific Issues Instruction to Fostering Students' Decision-making Based Gender on Environmental Pollution. *Journal of Physics: Conference Series*. Vol. 812, No. 1.

Rundgren, C. J., M. Eriksson, and Chang S. N. Rundgren. 2016. Investigating the Intertwinement of Knowledge, Value, and Experience of Upper Secondary Students'. Argumentation Concerning Socioscientific Issues. *Science and Education.* Vol. 25. pp. 1049–1071.

Saller T. D. and zeidler, D. L. 2003. The Morality of Socioscientific Issues: Construal and Resolution of Genetic Engineering Dilemmas. Wiley Interscience. pp. 4–27.

Sadler, T. D. and D. L. Zeidler, 2004. The Significance of Content Knowledge for Informal Reasoning Regarding Socioscientific Issues: Applying Genetics Knowledge to Genetic Engineering Issues. *Science Education.* Vol. 89, No. 1. pp. 71–93.

Sadler, T. D. 2002. Socioscientific Issues and the Affective Domain: Scientific Literacy's Missing Link. Paper Presented at the 2002 Annual Meeting of the Southeastern Association for the Education of Teachers in Science, Kennesaw, GA.

Sadler, T. D. 2003. Informal reasoning regarding socioscientific Decision-making as integral components of scientific litenacy. Spring, 13CD, 39-48.

Sadler, T. D. 2004a. Moral and Ethical Dimensions of Socioscientific Decision-making as Integral Components of Scientific Literacy. *Spring.* Vol. 13, No. 1. pp. 39–48.

Sadler, T. D. 2004b. Moral sensitivity and its contribution to the resolution of Socio-scientific Issues. *Journal of Moral Education*. Vol. 33, No. 3, pp. 339–358

Sadler, T.D., A. Amirshokoohi, M. Kazempour, and K. M. Allspaw, 2006. Socioscience and Ethics in Science Classrooms: Teachers' Perspective and strategies. *Journal of Research in Science Teaching.* Vol. 43, No. 4. pp. 353–376.

Sharma, A. 2007. School Science and Students in Rural India: Do the Twain Ever Meet? Contemporary Education Dialogue. Vol. 5, No. 1. pp. 28–63.

Shwartz, Y., R. Ben-Zvi, A. Hofstein. 2006. The Use of Scientific Literacy Taxonomy for Assessing the Development of Chemical Literacy among High-school Students. *Chemistry Education Research and Practice.* Vol. 7, No. 4. pp. 203–225.

Singh, S. and S. Singh. 2016. What is Scientific Literacy?: A Review Paper. *International Journal of Academic Research and Development.* Vol. 1, No. 2. pp. 15–20.

Thareja, S. 2015. End the Debate.... CBSE V/s ICSE. *Towards Excellence: An Indexed, Refered at Peer Reviewed Journal of Higher Education.* Gujarat University. Vol. 7, No. 2. pp. 45–50.

The Constitution of India, 26 January. 1950. Retrieved 30 May 2018, from http://www.refworld.org/docid/3ae6b5e20.html

Watts, M. 2000. The Affective Dimensions of Learning Science. *International Journal of Science Education.* Vol. 22, No. 12. pp. 1219–1220.

Webb, P. 2009. Towards an Integrated Learning Strategies Approach to Promote Scientific Literacy in the South African Context. *International Journal of Environmental and Science Education.* Vol. 4, No. 3. pp. 313–334.

Yang, F. Y. 2004. Exploring High School Students' Use of Theory and Evidence in an Everyday Context: The Role of Scientific Thinking in Environmental Science Decision-making. *International Journal of Science Education.* Vol. 26, No. 11. pp. 1345–1364.

Yates, B. L. 1998. Achieving Scientific Literacy through the Mass Media and other Communication Technologies: A NASA Perspective. Paper Presented At Florida Communication Association.

Yoonjeong, L., J. Eunjeong, S. and Jang. 2016. Examining Elementary School Students' Awareness about Socio-scientific Issues and Solutions about Environmental Topics by Using their Drawings. *Journal of Korean Elementary Science Education.* Vol. 35, No. 1. pp. 111–122.

Zeuidler, D. L. and B. Nichds, 2009. Socioscientific issues: Theory and Practice. Journal of Elementary Science Education, 21 (2), 49-58.

Zeidler, D.L. 2003. The role of moral reasoning on socioscientific issues and Discourse in Science Education. The Netherlands: Kluwes Academy Press.

Zeidler, D. L. 2014. Socioscientific Issues as a Curriculum Emphasis. In Abell, S. K. Lederman, N. G. (Eds.), *Handbook of Research on Science Education.* (pp. 697–726). Lawrence Erlbaum. Mahwah, NJ.

Zeidler, D. L., and L. E. Schafer. 1984. Identifying Mediating Factors of Moral Reasoning in Science Education. *Journal of Research in Science Teaching.* Vol. 21. pp. 1–15.

Zeidler, D. L., J. Osborne, S. Erduran, S. Simon, and M. Monk. 2003. The Role of Argument During Discourse about Socioscientific Issues. In D. L. Zeidler (Ed.), *The Role of Moral Reasoning on Socioscientific Issues and Discourse in Science Education.* (pp. 97–116). Kluwer. Dordrecht, The Netherlands.

Zeidler, D. L., K. A. Walker, W. A., Ackett, and M. L. Simmons. 2002. Tangled up in Views: Beliefs in the Nature of Science and Responses to Socioscientific Dilemmas. *Science Education.* Vol. 86, No. 3. pp. 343–367.