Teachers' perspectives on teaching of Socio-scientific Issues (SSIs) in Indian Science Classrooms

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The candidate confirms that the work submitted is his/her own and that appropriate credit has been given where reference has been made to the work of others.

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Abstract

This thesis explores the teachers' perspectives on the teaching of Socio-Scientific Issues (SSIs) and the factors that influence their teaching. SSIs are those contemporary issues that are deep rooted in sciences, have an impact on society, involve moral and ethical reasoning and are controversial in nature. The study has been conducted in the context of Indian science classrooms, with fourteen upper primary and secondary stage science teachers from five schools. Three of the five selected schools are Green Schools, which have an explicit focus on the teaching of environmental SSIs. The data was collected using semi-structured interviews and classroom observation sessions, with a focus on following two questions. (1) What are the methods and strategies used by the teachers for teaching SSIs? (2) What are the factors that influence the teaching of SSIs?

The results showed that the majority of teachers supported the teaching of SSIs and for some this links to specific SSIs in their lives and local communities in their Indian context, particularly pollution and environmental threats. However, a significant level of variation was witnessed in their actual classroom practices for teaching SSIs. The various profiles of teachers, classified based on their beliefs and classroom practices, have been discussed. Among the methods used by the teachers for teaching SSIs, the two most common method for teaching SSIs were discussions and lecture method. Four different forms of discussions and two different forms of lecture method have been delineated based on the strategies used by the teachers for teaching SSIs. Results indicated that teachers' beliefs, school leadership and assessment system are the most influential factors for SSIs teaching. Implications and the major findings of this research have been discussed which contribute towards the acute lack of empirical studies over the teaching of SSIs in Indian schools.

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List of Abbreviations

AS Level	Advanced Subsidiary Level
BT Cotton	Bacillus Thuringiensis Cotton
CBSE	Central Board of Secondary Education
CCE	Continuous and Comprehensive Evaluation
CMEC	Council Of Ministers Of Education, Canada
CPCB	Central Pollution Control Board
CSE	Centre for Science and Environment
CVE	Certificate of Vocational Education examination
DDT	Dichlorodiphenyltrichloroethane
ECO	Ecology
FA	Formative Assessment
GM	Genetically Modified
CISCE	Council for the Indian School Certificate Examinations
ISC	Indian School Certificate examination
MPE	Mathematics of Planet Earth
NCERT	National Council of Educational Research and Training
NFG	National Focus Group
NoS	Nature of Science
PCC	Pollution Control Committee
PETA	People for Ethical Treatment of Animals
POS	Perspectives on Science
QCA	Qualifications and Curriculum Authority
RQ	Research Question
RSPM	Respirable Suspended Particulate Matter
SA	Summative Assessment
SL	Scientific Literacy
SPCB	State Pollution Control Board
SSI	Socio-Scientific Issue
STS	Science Technology and Society
TAP	Toulmin's Argumentation Pattern

Chapter 1 Introduction

This research is focused on the teachers' perspectives on teaching of SSIs in Indian science classrooms. I plan to investigate teachers' perspectives on the teaching of SSIs in particular; different methods and strategies employed by teachers for teaching SSIs and their rationales for using these methods and strategies; the factors that influence the teaching of SSIs. My study will be based on the study of the teachers teaching science to upper primary stage (6^{th} to 8^{th} standard- 11 to 13 years old) and secondary stage (9^{th} and 10^{th} standard, 14-15 years old). I propose to use an exploratory study design frame for my study. This chapter outlines the reason for doing this study, what are socio-scientific issues (SSIs) and how they are defined in this study. This section provides introduction to the relevant concepts and the aims of my study.

1.1. Scientific literacy context

We are living in the 21^{st} century, and are experiencing a series of momentous changes and development in science and technology. This advent of a rapid rate of change has presented our modern society with a range of many new dilemmas. Many major issues confronting our society have a close contact with science and technology. Considering that there have been many changes in the contemporary society caused by scientific and technological developments, it is somehow important to consider the ethical and moral grounds to understand science as a social enterprise. With this change in contemporary society, the goals of science education have also been modified in the past few decades to address the need of the future citizen. Osborne (2007) believed that simply presenting students with science knowledge does not serve the purpose. It also requires a visionary shift, which focuses on *how* this knowledge is related to students' daily lives and *why* it is important to understand the societal relevance of science. This vision of science education is broadly conceptualized as 'scientific literacy' (Millar and Osborne, 1998). Scientific literacy goes beyond scientific and technological understanding of concepts and includes the ability to use science in everyday life, display attitudinal

changes and to have the knowledge to connect science to other human endeavours (Norris and Phillips, 2003).

The attainment of scientific literacy has hence become one of the most important aims of school science education across the world. CMEC (Councils of Ministers of Education, 1997, p.4) defined scientific literacy as *"an evolving combination of science related attitudes, skills, and knowledge students need to develop inquiry, problem-solving, and decision-making abilities, to become lifelong learners, and to maintain a sense of wonder about the world around them"*. The Twenty First Century Science (2008) project developed in the English context also aimed to teach science in a way to make students scientifically literate, so that they are able to understand how science works. They view scientific literacy (SL) in a more practical way so that students *"have a broad understanding of the main scientific explanations that give [them] a framework for making sense of the world around [them]"* (Twenty First Century Science, 2008). This was also highlighted by Roberts (2007) in his vision of scientific literacy where Vision I looks 'inward' at science that includes the products of science i.e. the theories, laws, principles and other factual knowledge of science whereas Vision II looks 'outward' towards the situations that have a component of science and will be encountered by the students in their day to day life. This may also involve issues that require students' personal decision making skills based on the scientific outlook and the relevance of particular instances to them as a citizen of their country. Vision I more significantly refers to the traditional science practice that focuses more on the understanding and the knowledge aspect of science. The addition of a new aspect was also emphasised by Miller (1983,p.31) where he said that *"if scientific literacy is to become truly relevant to our contemporary situation, one additional dimension must be added: awareness of the impact of science and technology on society and the policy choices that must inevitably emerge"*.

Different variations can be found in the literature addressing this change in goals of science education. Jenkins (1999) perceived scientific literacy in terms of "citizen science". He described "*citizen science*," as "*a form of science that relates in reflexive ways to the concerns, interests and activities of citizens as they go about their everyday business*" (Jenkins, 1999, p.704). The importance of citizenship education in sciences was also highlighted by Pike (2007) who believed that students need to be necessarily scientifically literate to voice their opinion about SSIs prevalent in the

society and hence make knowledgeable decisions regarding their social repercussions. He asserted that this will help the students to gain the ability to consider ethical implications and make choices accordingly. The Qualifications and Curriculum Authority (2007) stated that citizenship education *"equips young people with the knowledge, skills and understanding to play an effective role in public life"* and *"encourages them to take an interest in topical and controversial issues and to engage in discussion and debate"*. (QCA, 2007b,p.27), (QCA, 2007a,p.44). Nevertheless, both scientific literacy and citizenship education are committed to the notion of preparing 'children for life, (Pike, 2007,p.215). This perspective has been clearly articulated in the White Paper on Education and Training (European Commission. Directorate-General XXII. Education and Youth, 1995) that preparing students for society *"does not mean turning everyone into a scientific expert, but enabling them to fulfil an enlightened role in making choices which affect their environment and to understand in broad terms the social implications of debates between experts*" (European Commission. Directorate-General XXII. Education and Youth, 1995, p.11-12). Engaging students in issues that allow them to explore different opinions and consider a range of political, social, ethical and moral problems will be helpful to develop their critical skills (QCA, 2007b, QCA, 2007a). For such issues, Sadler and Zeidler (2005) used the term Socio-scientific issues (SSIs) to include those distinct features apart from scientific and technological content that are controversial in nature and are subjected to political and ethical influences.

1.2. Socio-scientific Issues and their inclusion in school science curriculum

Socio-scientific issues generally stem from *"biotechnological advances such as cloning, stem cells, and genetically modified foods and environmental challenges such as global climate change [and] land use decisions"* (Sadler and Zeidler, 2005,p. 112). These issues arise from the social, ethical, and moral conflicts caused due to the advancement of science and technology in almost every aspect of human activity (Lee and Witz, 2009). Henceforth, SSIs tend to represent a variety of social dilemmas having a conceptual or technological association with science (Kolstø, 2001, Zeidler et al., 2002) and are contentious in nature (Sadler, 2004). It is to be noted here, that

importance given to any SSI may vary across societal settings, this localised nature of SSIs was highlighted by Ratcliffe and Grace (2003) where they described general characteristics of these issues as: *"important for society and have a basis in science, involve forming opinions, are frequently media-reported, address local, national and global dimensions with attendant political and societal frameworks, involve values and ethical reasoning, may involve consideration of sustainable development and may require some understanding of probability and risks, and there are no right answers".* Since SSIs are a particular type of social issues that are scientific in nature; hence decisions regarding them are generally impacted by economic, political, legal, or religious factors (Barab et al., 2007) and involves making value judgements by coordinating scientific knowledge with ethical and personal concerns (Sadler and Zeidler, 2004).

Miller (1983) notably mentioned that decision about the issues of pollution and other environmental challenges that require people's understanding about these issues to envisage their effects and make a knowledgeable decision fall in the zone of STS (Science, Technology and Society). This idea was popular in early 1980s and authors like Jenkins (2002) have suggested that STS is an underdeveloped idea, which lacks theoretical framework to be used as a pedagogical strategy. Sadler and Zeidler (2005) distinguished SSIs from the STS by stating that as compared to STS, SSIs focus more on enabling students to understand that decision made about science based-issues reflect students' own moral principles in the way that how they comprehend their own lives and the world around them (Driver et al., 1996, Driver et al., 2000, Kolstø, 2001, Sadler, 2004). Zeidler et al. (2002,p.334) also pointed out that, *"Socio-scientific issues then, is a broader term that subsumes all that STS has to offer, while also considering the ethical dimensions of science, the moral reasoning of the child, and the emotional development of the student".* It can be inferred from this that SSIs adds a controversial dimension that considers the ethical and moral reasoning of a child quite important to understand the scientific issues surrounding them in society.

In my thesis, based on the interpretation of all the above definitions, SSIs are those contemporary issues that are deep rooted in sciences, have an impact on society, involve moral and ethical reasoning and are controversial in nature. It is

evident that impact of science on society and vice-versa has become quite prominent in past few decades. What differentiates SSIs from other scientific and technological issues is the involvement of controversial aspects and the ethical or moral reasoning involved with these issues. There are many examples like cloning, genetic manipulation, use of atomic and nuclear bombs, experiments on animals, global warming etc. that are termed as SSIs. I think that many of these issues were not present in society before and have arisen with the change and innovation in the technology. Hence, it can be contemplated that SSIs will vary with time and changes in society and sciences. Their inclusion in the science curriculum may also vary accordingly.

Lately, there has been an increased amount of emphasis on the development of conceptual frameworks, which include moral and ethical dimensions for incorporating scientific literacy in students. The controversial, moral and ethical dimensions of SSIs require students' intellectual, sociological and informal reasoning to understand these issues and make an informed decision (Zeidler and Keefer, 2003). Dealing with contemporary SSIs provides students with a context where they can integrate scientific concepts with their personal-life experiences. This kind of platform provides the student with an opportunity to develop their understanding of scientific concepts that in turn influence their informal reasoning related to SSIs (Sadler, 2004). In a similar vein, Reis and Galvão (2009) also concluded that discussing SSIs in the classroom helps the students to learn the basic concepts of sciences (Reis and Galvão, 2009). They also identified that teaching SSIs in the classroom prepares the "student for life" and "for making decisions as citizens" (Reis and Galvão, 2009). This idea of preparing "children for life" was also expressed by (Pike, 2007, p. 215). Rundgren and Rundgren (2010) also stressed that since SSIs have multifaceted characters, they can be viewed from multiple perspectives and hence provide the students with the understanding of cross-disciplinary concepts. According to them, there are different outcomes that can be achieved through teaching of SSIs.

Teaching of SSIs not only helps in achieving goals of scientific literacy but also helps in the transmission of scientific knowledge to real life contexts, promotes ability of critical thinking and decision making; and also induces interest in learning

sciences. Kolstø (2001,p.291) also emphasised the role of *"science as citizenship*". However, he considered SSIs should be given a significance importance in science for citizenship education as these issues are often highlighted in media or students come to confront them in their day-to-day life because of their localised nature. He articulated the issues, that involve risk of health or environment, allow the students to evaluate the risk and take decisions accordingly.

Agreeing with this idea, it can be inferred that teaching of SSIs helps the students to understand the intricacies of the interface between science and society, which help them to take informed decisions. The importance of informed decision-making was also emphasised by Zeidler et al. (2005). They explored that the growing professional links across the world in the field of science education has acquainted us with a need to intellectualise scientific literacy in a broader way that include *"informed decision making; the ability to analyse, synthesise, and evaluate information; dealing sensibly with moral reasoning and ethical issues; and understanding connections inherent among socio-scientific issues (SSIs)*" (Zeidler et al., 2005, p.357-358). Pouliot (2008) also supported the same thought as according to him study of SSIs help the students in evaluating scientific information and to make decisions regarding controversial issues concerning them.

In summary, the inclusion of SSIs helps in developing a 'scientific temper' (NCERT, 2014, p.11) where students can think rationally, evaluate the scientific information, analyse and integrate the scientific knowledge with their moral and ethical reasoning, keeping in mind their daily experiences to take an informed decision. Along with the development of decision making skills, teaching of SSIs also engage students in inquiries related to science as well as in their day to day experiences (Zeidler and Keefer, 2003). Inclusion of SSIs in the science curriculum for achieving scientific literacy has also been promoted by several other science education researchers (Kolstø, 2001, Millar et al., 2002, Sadler and Zeidler, 2004, Zeidler and Keefer, 2003). Scientific literacy can play a strong role in defining a unique link between science, technology and society. It not only helps in understanding of scientific concepts but also helps to view *"science as a social enterprise"* (Driver et al., 1996, p.12-13), (NCERT, 2005). This will further help the

students to understand the predominance of science and technology in society and take actions accordingly (Driver et al., 1996).

1.3. The Science Curriculum in Indian context

The curriculum framework for schools in India is developed through the help of the National Council for Educational Research and Training (NCERT). NCERT is an organisation that has been set up by the Government of India to advise and assist Central and State boards on academic matters related to school education. A panel of esteemed scientists and educators develop the science curriculum under NCERT. The government of India has provided the state governments with the freedom to modify and develop the curriculum based on the social, economic and cultural needs of the people, the content of the NCERT textbook is still widely accepted (Press Information Bureau, 2005).

In 2005, the NCERT proposed a new Indian National Curriculum Framework for teaching and learning science. Twenty-one National Focus Group Position Papers were developed that covered the areas of curricular concern, areas for systemic reform and national concerns. The Position Paper on Teaching of Science covers the science curriculum that needs to be employed at national level, the lessons from different intervention programmes, and aims of science education and curriculum organisation at different levels, key issues and concerns that need to be addressed (NCERT, 2014). They intend to design what needs to be taught in the science classrooms.

The Indian science curriculum is based on six basic criteria of validity of the science curriculum (NCERT, 2005). They are called cognitive validity (child-centred content, process and teaching practice), content validity (use of scientifically correct content), process validity (helping the student in learning how to learn science), historical validity (change in the concepts of science with time and how development of science is influenced by society), environmental validity

(understanding of the interface of science, technology and society) and ethical validity (encouraging honesty, objectivity and developing concern for life) (NCERT, 2005). Preparing scientifically literate citizens is stated as one of the major goals of science education in India (NCERT, 2005). The science curriculum up to 10th standard (up to the age of 15) is designed with the aim to make the students scientifically literate since many of the contemporary controversial issues in our society increasingly revolve around science and technology. It has been clearly stated that "*the science curriculum up to [10th standard] 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*" (NCERT, 2014, p.11). The curriculum writers further recommended that science curriculum should be "placed in the wider context of the learner's environment, local and global, enabling him/ her to appreciate the issues at the interface of science, technology and society" (NCERT, 2005, p.3).

Furthermore, science curriculum should facilitate the students to develop critical thinking, objectivity and concern for life and environment. The teachers are expected to change their pedagogic practice accordingly. The way the curriculum should be implemented is the sole responsibility of the teacher (Desouza et al., 2004). There are some suggested guidelines on the use of resources and activities or methods that teachers can use to teach. Some of these are engaging students in group activities, debates, discussions, surveys, participating in national fairs and science exhibition, taking up projects on local issues and other co-curricular activities. However, the National Focus Group (NCERT, 2014) lacks guidance on specificities of how this can be done.

Hipkins et al. (2005, p.246) highlighted a similar issue in the context of New Zealand science curriculum where *"in the absence of clear directives about NOS in the New Zealand science curriculum, other more implicit curriculum messages continue to hold sway"*. In this case teachers interpreted the curriculum differently and dropped out the topics related to Nature of Science (NOS) and focused on the "content" that they perceived as important for exam success. Here, their interpretation of the term "learning needs" was linked to students' success in exams.

Hipkins et al. (2005, p.248) further suggested that curriculum standards expect teachers to *"integrate multiple demands in the moment in the classroom"*. This implies that the rhetorical task that curriculum writers expect teachers to interpret and follow in the classroom turns out to be different *"when confronted with the realities of established scientific knowledge, and the pressures of classroom life, and of assessment and accountability regimes*" (Feinstein, 2011, p.169). In a similar vein, the Indian teachers are provided with the liberty to design their own instructional programs to teach within the classroom. According to Rajput (2000, p.4) the National Policy of School Education in India, in 1982 and later in 1992, *"placed complete trust in the teaching community and calls for substantial improvements in the quality of teacher education and emphasises teachers are accountable to pupils, the parents, the community and their own profession"*. Though the teachers are provided the liberty in the written curriculum, they are still tied to the guidelines of the curricula and assessment. It will be interesting to observe whether what Indian science curriculum offers' has been implemented in the classroom or has been reduced to a rhetorical claim.

It has been known that the curriculum reform in 2005 in India was developed in accordance with the standard of science instruction in the USA (Chiu and Duit, 2011). However, the application of the basic concepts is in context with the Indian society. The teachers are provided with a westernised curriculum, to be applied in the Indian setting without making them aware of how to teach within this new framework. This was also highlighted by Nargund-Joshi et al. (2011) (cited in Chiu and Duit (2011)) in their two case studies conducted on Indian teachers. They concluded from their study that the views and orientations of teachers were in accordance with the new curriculum; however the mode of instruction was different from the one requested by the new framework. It became a strenuous task for the teachers to strike an optimum balance in teaching a socially and culturally sensitive curriculum and helping students develop a scientific temperament that are necessary for problem solving and decision making.

In keeping with these curricular demands, the chairperson of the National Council for Educational Teacher Education, Dr. A. N. Maheswari (Maheshwar, 1993) explained that students should not only learn science, but be exposed to a curriculum

that prepares them to live a sustainable life style. As a direct consequence of this viewpoint, it is important to presently consider 'what, how, and who teaches science in Indian classrooms' (cited in Desouza et al. (2004)). In this study I wish to explore 'how' socio-scientific issues are taught in the Indian science classrooms. It is to be noted that the term SSIs has not been referred to in the curriculum as such, however the topics included in the curriculum that refer to the ethical and environmental validities (e.g. pollution, global warming etc.), reasonably fall under the umbrella of SSIs. These topics are included in the curriculum in the context of the Indian scenario.

1.4. Focus of the Study

This research is focused on the teaching of socio-scientific issues in Indian science classrooms. I plan to investigate what are the methods and strategies that teachers use to teach SSIs, the underlying rationales for choosing those methods and the factors that influence the teaching of SSIs. There have been many studies on teaching of SSIs across the world; however I have not come across any study based in Indian schools. It has been mentioned before (section 1.2) that teachers have the freedom to design their own instructional approach. Teachers' interpretations of the science curriculum can differ. They may have an understanding of what SSIs are and what curriculum demands from them to teach, there is no guarantee that teachers are doing what curriculum writers expect them to do. It can be concluded from the previous research that teachers still find it difficult to follow the new approach and hence try to remain intact with the traditional teaching methods only. SSIs are contemporary and socially and ethically controversial in nature, so I think it is necessary to adopt a new approach towards teaching these issues. These issues require a student to develop their own rational thinking and "scientific temper" (NCERT, 2005, p.11) which cannot be imparted by just passing on the scientific knowledge. Keeping in mind all these points my study will be based on the teachers teaching science to upper primary stage (6th to 8th standard- 11 to 13 years old) and secondary stage (9th and 10th standard, 14-15 years old). Teaching of SSIs to this age group may bring upon changes in the future, as the teachers may help the students to explore and understand the seriousness of these issues and their impact on society. This may not only make students scientifically literate but may also help them to engage and decide on the issues that relate to both science and society. In

my opinion, the teachers teaching this age group (11-15 years old) play an important role in channelling and guiding the young students' thought processes and ideas. Hence, I feel those teachers' perceptions about SSIs and their thoughts about teaching these issues in the classroom are likely to play a pivotal role in their teaching besides their subject knowledge. I am not trying to judge their teaching but I am interested in knowing their understanding, the approach they follow and the idea they hold for these issues. Since the intensity of a particular SSI affecting a society may vary with time, so it needs to be noted that the teachers' perceptions and their outlook towards teaching that SSI may also vary with time.

1.5. Structure and content of the thesis

Chapter 1 provides background on the Socio-Scientific Issues (SSIs) and their pedagogical relevance in science curriculum. It further discusses the idea of scientific literacy and provides grounds for incorporating SSIs into the science curriculum as a means for achieving scientific literacy.

Chapter 2 reviews the literature on the research into the various facets of the teaching of SSIs from teachers' perspectives. In particular, the various perspectives of teachers on teaching of SSIs delineated in the literature are discussed. Further, the main findings of these studies concerning the methods and strategies employed by teachers for teaching SSIs are described. Lastly, the various impactful factors, reported in the literature in the context of SSIs teaching, are elaborated.

Chapter 3 presents the detailed research questions.

Chapter 4 is a description and justification of the research methodology. A case study design frame was used for data collection. This chapter includes an account of the piloting report and the follow-up changes. It describes the collection of the data, vignettes of the different schools, a brief overview of the boards they belong and clarification of the conceptual terms that will be addressed in the following sections.

Chapter 5 focuses on the findings of the teaching and learning methods and strategies for teaching SSIs, and teachers' rationales for using the methods and strategies, identified in this study. Through a range of interviews and observations

carried out in the context of this study, four main methods, used by teachers to teach SSIs, were delineated. They are discussion method, debates, lecture method and other different approaches used in school by science teachers to teach SSIs. The four methods are described and analysed in this chapter.

Chapter 6 focuses on the factors that influence the teaching practices of SSIs. This chapter reports on a number of factors that, based on the analysis of the data in this particular study, influence the teaching of SSIs.

Chapter 7 discusses the two Research Questions (RQs), addressed in this study, in light of the main findings presented in the previous chapters. Subsequently, the educational significance of this study is discussed, along with the possible implications of the results, with a specific focus on the curriculum development and the design of science teaching.

Chapter 2 Literature Review

This chapter comprises of a review of the literature, relevant to my study. The literature review, which establishes the context for the research questions investigated in this thesis, has been structured into three main parts. The first part provides a review of the existing literature on teachers' perspectives about the teaching of SSIs, and their perceptions and in-classroom actions related to SSIs teaching. The second section reviews the literature on the different strategies and methods teachers use to teach SSIs, and the conceptual models developed by the researchers thereof. The third section considers the literature regarding the factors that impact the teaching of SSIs.

2.1. Teachers' Perspectives on the teaching of SSIs

Teachers are the primary facilitators and actual implementers of the curriculum (Lee et al., 2006, Ramsey and Howe, 1969). The strong commitment of teachers is therefore critical to any effort or reforms aimed at transforming the focus of science curriculum from transmission of factual knowledge towards scientific literacy (Driver et al., 2000, Hodson, 2003, Witz and Lee, 2009). Few would question the importance of teachers' perspectives to the science education. In fact, a considerable amount of research has been conducted on capturing teachers' perceptions on the various aspects related to science education, including the teaching of SSIs. The diverse aspects related to teachers' perceptions over SSIs teaching include, the variations in perceptions of teachers, perceptions on specific targets, e.g., subject content, factors that influence teachers' perceptions, and the rationale behind or the origin of teachers' perceptions (Barrett and Nieswandt, 2010, Nespor, 1987, Pajares, 1992). Some of the existing studies that explored the teachers' perceptions regarding the teaching of SSIs are discussed further in this section.

It is challenging for a researcher to clearly disentangle the views teachers hold about SSIs as an adult and that as a science teacher who is responsible for teaching SSIs as a part of the science curriculum. This challenge is further exacerbated by the fact that teachers themselves are at times confused between these two views (Barrett and Pedretti, 2006). Lazarowitz and Bloch (2005) spotlighted this difficulty in their study of 30 high school biology teachers, wherein they aimed to explore the awareness of societal issues (including, their moral, ethical, values and legal aspects) while teaching genetics. They reported that "*it remains to be determined if teachers lack sensitivity to societal issues or do not regard it their role as science teachers to include values and ethical aspects"* (p. 446). This particular statement highlights the level of difficulty in addressing teachers' views on SSIs, as their lack of interest in teaching SSIs could be rooted in their lack of sensitivity towards the ethics and morality behind SSIs or they simply are indifferent about the inclusion of SSIs in the sciencecurriculum.

In addition to the entanglement of the perspectives of teachers as adults and teachers as professionals, a further misunderstanding exists between the terms teachers' beliefs and perspectives. These two terms are more often than not used interchangeably in the literature. The difference between these terms first received attention by Tabacbnick and Zeichner (1984) and Goodman (1988). Unlike beliefs that are considered as psychological constructs formulated by a person's personal, episodic and emotional experiences (Nespor, 1987), Tabacbnick and Zeichner (1984) concluded that perspectives include both the beliefs that teachers have about their work, goals, subject matter, roles and responsibilities and also "*the ways in which they [give] meaning to these beliefs by their behaviour in the classroom*" (p. 28). Clark and Peterson (1986) went a step further and defined teacher's perspective as "*a reflective, socially defined interpretation of experience that serves as a basis for subsequent action (…) a combination of beliefs, intentions, interpretations, and behaviour that interact continually*"(p.287). More specifically, teachers' perspectives take into account the situations that teachers experience in the classrooms, how teachers interpret these situations based on their beliefs, assumptions, and previous experiences and how teachers' interpretations are manifested in their behaviour (Goodman, 1988). Based on the above description, the perspective is hence, a broader term as compared to beliefs. Not only has it included beliefs, intentions,

interpretations, and behaviours, it is also situation specific and action oriented (Pajares, 1992). An attempt has been made in this thesis to use appropriate terminology, where applicable, when talking about teachers' perceptions and beliefs.

Numerous researchers provided insights into teachers' perspectives about the inclusion of controversial topics in their teaching (Anagün and Özden, 2010, Barrett and Nieswandt, 2010, Lee et al., 2006, Mitchener and Anderson, 1989, Sadler et al., 2006). One of the earliest studies on this topic was conducted by Mitchener and Anderson (1989), where they examined the teachers' perspectives about the inclusion of controversial topics in their teaching and developed three distinctive profiles of the teachers based on their findings. According to these three profiles, (1) a few teachers willingly incorporated these topics in their teaching to associate students' personal lives to science, (2) a few teachers resisted the inclusion of such topics as they believed that teaching of controversial topics should be a part of social studies teaching rather than being in the science curriculum, and (3) a group of teachers showed an inclination towards inclusion of these issues but stated numerous constraints that impeded them from implementing the curriculum (with such issues) in their classrooms. A similar variation of teachers' perspectives has been witnessed in other studies in the literature, out of which a few closely relevant to my study are discussed further in detail.

In the context of SSIs, an exploratory study on profiling teachers based on their perspectives on SSIs teaching was conducted by (Sadler et al., 2006). In this study, Sadler et al. (2006) further refined the classification of teachers' profiles by Mitchener and Anderson (1989) into five profiles. Their study was conducted with 20 middle and high school science teachers. In addition to recording teachers' perspectives on SSIs teaching, Sadler et al. (2006) also explored into the ways the teachers handled SSIs teaching in their classrooms. Five profiles (Profiles A - E) capturing the diversity of the teachers' perspectives on the importance of SSIs in science education and teachers' practices for teaching SSIs were delineated in this study. Table 2.1 provides the details into the variation at the level of perspectives and practices of the teachers in these profiles. The five profiles delineated by Sadler et al. (2006) are as follows: Profile-A teachers explicitly embraced the inclusion of SSIs in science education. They not only contended this in their interviews but

researchers found Profile-A teachers actively teaching SSIs in their classrooms. Profile-B teachers, similar to Profile-A, revealed their inclination towards the importance of including SSIs in science curriculum, but did not show similar commitment in practice due to some contextual factors (described further in this chapter). A dichotomy in the Profile-C teachers' perceptions about SSIs was witnessed. They, on one hand, accepted the ubiquitous nature of SSIs in today's society, but, on the other hand, disagreed with the notion of teaching of ethical aspects of SSIs. They posited that it is the duty of social science teachers to teach about the ethical, moral or emotional ramifications of SSIs and science teachers' job is to focus on the teaching of canonical science. Profile-D teachers more strongly advocated this notion and openly rejected the inclusion of values, or any form of discussion related to ethics as a part of science. In complete contrast to Profile-D, Profile-E teachers undertook a strong pro-SSIs stance where they felt an "ethical obligation" towards students for teaching them about ethics and values, irrespective of the subject in which they are taught. Profile-E teachers believed that even if they were teaching a subject other than science, they would still make students aware about SSIs in one way or another. Overall majority of teachers including those who disagreed with the idea of teaching SSIs (in science classrooms) believed that teachers should not impose their views and values on students.

The five profiles in Table 2.1 are the most specific classification of teachers' profiles that I encountered in my literature review. Hence, these five profiles have been chosen as a reference to compare against the profiles delineated by other similar related studies on teachers' perspectives and practice of SSIs teaching. Three more studies covering the teachers' perceptions on SSIs teaching, i.e., Anagün and Özden (2010), Barrett (2008), and Barrett and Nieswandt (2010) were found. However, a detailed review of only Barrett and Nieswandt (2010) study has been further discussed, as this is the only study out of the three that explicitly categorised the profiles of teachers based on their practices and perspectives towards the teaching of SSIs. The other two studies, by Anagün and Özden (2010) and Barrett (2008) examine the perspectives of pre-service teachers undergoing training for science teaching about the teaching of SSIs. As these candidates were themselves the students of science education programmes no account of their teaching practice was available.

Table 2.1: Teachers Profiles based on their Perspectives and Practices with respect to SSIs. (Sadler et al., 2006)

Profile	Perspective	Practice
Profile-A	SSIs are an integral part of science curriculum Ethical and moral aspects of SSIs should be addressed	Addressed SSIs as a significant part of their teaching
Profile-B	SSIs are an integral part of science curriculum Ethical, moral and controversial aspects are a mean for helping students connect science to their real life	Cited a set of impeding factors that prevent them from teaching SSIs
Profile-C	SSIs are ubiquitous in nature Ethical and moral aspects are not necessarily an integral part of science curriculum	Believed that addressing ethical and moral aspects of SSIs is not a part of their role as a teacher
Profile-D	No intersection between ethics and science education Science is a value-free subject	Opposed the idea of introducing multiple aspects of SSIs in science curriculum
Profile-E	Ethics and values should be a part of entire education system, not just science	Believed in overall ethical development of students as an individual rather than just science students

Barrett and Nieswandt (2010) conducted a qualitative study with 12 physics and chemistry teachers participating in a teacher education course in Canada. This study further looked into the rationales behind these beliefs by exploring the origin of teachers' beliefs. The beliefs investigated were classified into two categories, 'espoused beliefs' and 'beliefs-in-use' (Kane et al., 2002). Espoused beliefs refer to the beliefs which teachers talk about when probed. Beliefs-in-use refer to the beliefs that are reflected by teachers' actions. Similar terminology has

been used further in my thesis when referring to the two forms of teachers' beliefs. Close interaction between both of these forms of beliefs and contextual factors around them, typically make it difficult to tell apart teachers' espoused beliefs from beliefs-in-use (Barrett and Pedretti, 2006). Barrett and Nieswandt (2010) aimed at carefully addressing this issue using in-depth interviews with teachers and the observation of their classrooms.

Classification of profiles by Barrett and Nieswandt (2010). Barrett and Nieswandt (2010) classified the teachers into groups based on their beliefs about the role of personal ethics of individuals (teachers or students) and ethical aspects of science in education. These groups are named as: Model Scientist/Engineer, Model Individual, Model Teacher, and Model Citizen. The Model Scientist/Engineer group believed that science education is free of ethics, i.e., it is a value-free subject. Both espoused beliefs and beliefs-in-use of teachers in this group were inclined towards not including SSIs in science education and considered science as an objective subject. This profile has similarities with the Profile-D teachers in Table 2.1. However, unlike the characteristics of Profile-D, the Model Scientists/Engineers agreed to the fact that it is difficult to remain absolutely objective in practice (beliefs-in-use). They believed that their (espoused) beliefs were a reflection of what they intended in an ideal scenario, i.e., not including any ethical or moral aspects in science education. Consequently, they contained any discussion on SSIs to a bare minimum and in case a situation arose where a discussion was necessary they tried to wrap it up in minimum possible time. Another aspect, in addition to the characteristics of Profile-D given by Sadler et al. (2006), is that Model Scientists/Engineers intended to develop the future generation of scientists, and considered value-free science education as the only means to do that.

The second category of teachers, i.e., Model Individuals in Barrett and Nieswandt's (2010) study, believed that there is no concept as science ethics and instead focused on personal ethics of an individual. Teachers believed that humans are either of good character or not. Hence, teachers primarily focused on developing good characters of their students beyond the confines of science. They did espouse the inclusion of SSIs in science education but were unable to implement it in-use due to their inability to recognise the ethics in science. Model Individuals can be mapped to the Profile-E teachers in the study by Sadler et al. (2006). However, no explicit

evidence was mentioned by Sadler et al. (2006), about the exclusion of the ethical aspects of science by Profile-E teachers, as is the case in Barrett and Nieswandt (2010) study. Additionally, the teachers in Sadler et al. (2006) study did adopt teaching of SSIs in practice, whereas in Barrett and Nieswandt's (2010) study the teachers mentioned that they are unlikely to specifically focus on including SSIs in their teaching.

The characteristics of the third category, Model Teachers in Barrett and Nieswandt (2010) study of teachers map to the characteristics of both Profile-B and Profile-C in Sadler et al. (2006) study (see Table 2.1). Model Teachers, similar to Profile-B and Profile-C teachers, believed that there is a significant overlap between individual ethics and ethics of science and both should be a part of education. Teachers considered themselves responsible for developing students as informed citizens and ethical scientists. They included SSIs in their teaching as a means to involve students. These teachers did occasionally follow their espoused views, but cited barriers that prevented them from implementing SSIs curriculum in practice. In contrast to Sadler et al. (2006) Profile-B and Profile-C teachers' motivations, the teachers in Barrett and Nieswandt (2010) study specifically mentioned a need for addressing SSIs so that the future generation of scientists have a societal consideration in their work. This aspect of Model Teachers' perspectives also contrasts to the considerations of Model Scientists/Engineers in the same study. Similar perspectives of teachers (Graduate Teaching Assistants - GTAs) were also witnessed by Gardner and Jones (2011), where all the participants in the study clearly supported the inclusion of SSIs instruction and considered it as paramount for producing scientifically literate citizens, but did not follow their espoused views in practice. The barriers (mentioned by the teachers across studies by Barrett and Nieswandt (2010), Gardner and Jones (2011), and Sadler et al. (2006), such as, the lack of time, vast curriculum, and personal insecurities that accounted for the difference in teachers' espoused beliefs and beliefs-in-use in these different studies have been discussed further in Section 2.3.

The last category of teachers, Model Citizens in Barrett and Nieswandt (2010) study were similar to the Sadler et al. (2006) Profile-A. They considered no difference between one's ethics from that of science ethics. They believed that they

would be at fault if they do not teach SSIs to students and a level of congruence was witnessed between their espoused beliefs and their beliefs-in-use.

Barrett (2008) compared the perspectives of pre-service teacher candidates enrolled in a science teacher education programme in southern Ontario, Canada to the perspectives of the instructors in the education programme about the teaching of SSIs. As a part of the study, the perspectives from 55 pre-service teacher candidates were compared to the perspectives of their instructors on teaching ethics through SSIs issues in the physics and chemistry. A majority of pre-service teacher candidates, 53 of 55 candidates, espoused the inclusion of SSIs in science curriculum. The two candidates that did not espouse the inclusion of SSIs cited the challenges of addressing SSIs and theoretical scientific content within allotted time frames and within the confines of vast curriculum, and the challenge of remaining neutral and not imposing their views on students while teaching SSIs. The instructors on the other hand, as reported in the study, did not show any inclination towards preparing these candidates for addressing societal/ethical aspects in their teaching. They felt that, given the time limits of the education program (nine months), their primary task is to prepare these candidates for more technical aspects of science teaching, such as, assessment. Additionally, they assumed that candidates themselves were not interested in discussing the possibility of teaching methods for addressing SSIs. It is inappropriate to compare characteristics of the candidates' profiles to the profiles in Table 2.1, as only their espoused views were available and not the practices. The instructors on the other hand resemble the Profile-C in Table 2.1 as they mentioned various other considerations for not discussing societal/ethical aspects in their lessons and did not show any concrete views on the inclusion of SSIs in science education.

Anagün and Özden (2010) conducted a study with 69 university level teachers in Turkey to explore teachers' views about the significance of SSIs in science and technology education. All the teachers were enrolled in a science-teaching program. A majority of teachers in this study, when surveyed, embraced the inclusion of SSIs in science education. However, a few teachers considered themselves as incompetent to hold a discussion about multiple-perspectives of SSIs with students. The science teachers that fully embraced the significance of teaching

SSIs both in their espoused views and practice did not receive any formal training on teaching SSIs. Still they taught SSIs, as they were personally motivated to do that. Previous researches show that the teachers that are internally motivated for teaching SSIs reflected moral and ethical values in their everyday teaching (Alexakos, 2005, Lee and Witz, 2009, Meis Friedrichsen and Dana, 2005, Reis and Galvão, 2004a, Witz and Lee, 2009)

Overall, in the four studies discussed above, i.e., Anagün and Özden (2010), Barrett (2008), Barrett and Nieswandt (2010), Sadler et al. (2006) it was found that none of the teachers or the pre-service teachers changed their beliefs over the period of the respective studies. The teachers that strongly believed in inclusion of SSIs in science curriculum did that irrespective of any barriers, any formal training in teaching of SSIs, or any other contextual factors. In contrast, the teachers that did not believe in inclusion of SSIs in science education (considered science to be a value-free subject) or repeatedly suggested externally imposed impediments, as the reason for not covering SSIs in their classrooms did not cover SSIs irrespective of the facilities or the teaching environment in their respective schools. Sadler et al. (2006) mentioned that it is highly unlikely that such teachers would cover SSIs in their teaching even if the external impediments were removed. This further relates to an important finding from by Lee and Witz (2009), Witz and Lee (2009) that the beliefs of teachers, in particular their beliefs-in-use are disconnected from any reform efforts. No external motivation, according to Witz and Lee (2009) can make teachers follow SSIs curriculum in a long run if they are not motivated from within. Hence, to bring any actual change or shift in terms of implementation of educational reforms in science curriculum, the researchers need to consider an in-depth exploration and interrogation of teachers' beliefs and the origin of teachers' beliefs (Bryan and Atwater, 2002, Lee and Witz, 2009)

Where the previously discussed studies focused on the teachers' perspectives on the teaching of SSIs, Lee et al. (2006) conducted a study to explore science teachers' perception about SSIs. They also investigated the factors that influence the teaching of SSIs. The data was collected from 86 middle and high school science teachers in Korea using a questionnaire from all the teachers and subsequently, via semi-structured interviews from a subset of 12 teachers. Three

distinctive sets of teachers' perspectives on SSIs were witnessed. The first set of teachers shared a negative outlook about SSIs. They believed that the negative side effects of SSIs, such as cloning and environmental issues go against the rules of nature and religion. One of the teachers termed scientists as scarier than "psychos" in society (and others termed them as "dangerous" and "destructive" (p. 104)), referring to the scale at which the scientists' deeds (negatively) impact the society. The second set of teachers felt that when deciding about SSIs, humans generally just act according to their desires, and instead should use their moral-ethical judgement. They mentioned that scientific developments are good for the human race but are also intervening with nature's course, which needs to be controlled. The teaching of SSIs, according to these teachers is important, as it would entail moral-ethical consideration in students to envision harmful effects of SSIs before they start and to curb *"the human desire to intervene in the natural principles of life and the environment"* (p. 105). The third set of teachers believed that SSIs are a consequence of a natural order of developments in science. They agreed that moral and ethical aspects are an integral part of science, and science is subjective by nature. Overall almost all the teachers agreed on the importance of SSIs and their teaching for students. They espoused the need to help students relate SSIs to their daily lives in order to develop moral-ethical judgement in students. The teachers that carried a negative outlook of SSIs emphasised on teaching SSIs to students in order to develop the ability in students to voice their opinions as citizens. Despite being strongly vocal about the importance of SSIs and their teaching, the majority of teachers did not include SSIs in practice and merely discussed them at a bare minimum level, whenever they felt the need to gather the attention of students. The notion of importance attached to the teaching of SSIs by the teachers to a large extent seemed to be actually the importance teachers attached to the issues personally. This refers to the challenge in nuancing the perspectives of teachers about SSIs and teaching of SSIs, as discussed at the beginning of this section. This ensures that it is not just difficult for researchers or readers to construe the difference between teachers' perspective on SSIs and teaching of SSIs, but also for the teachers themselves.

To gain insight into the deeper motivations of teachers to teach SSIs Lee and Witz (2009) conducted a study with four high school science teachers in the US. The data was collected by multiple in-depth interviews with the teachers. The study

was conducted with a hypothesis that teachers' perceptions and philosophies are disconnected from the reforms aimed at SSIs-oriented teaching. Teachers largely teach based on what they believe in, and their beliefs, ideologies, and values are disparate from the reform efforts (Aikenhead, 2006, Davis, 2003, Witz and Lee, 2009). There have been numerous examples of teachers referred in existing literature, that despite reform efforts, teachers could not relate to teaching of SSIs and felt that their primary task is to teach principles of facts of science and science is a purely objective subject (Cross and Price, 1996, Hansen and Olson, 1996, Jenkins, 2002, Witz and Lee, 2009). In contrast, there are teachers that teach SSIs even without any external influence, as they were internally (personally) motivated to teach SSIs rather than being externally motivated by reforms. Lee and Witz (2009) purposefully sampled four teachers that were known to have embraced the teaching of SSIs in their practice. The rationales and beliefs behind embracing SSIs, for these teachers, in practice originated from different aspects in teachers' biographies. The first teacher in this study worked as a scientist before taking up the job as a teacher. His close association with science infused a sense of responsibility in him to teach his students to be scientifically literate. A similar teacher was present in Barrett and Nieswandt (2010) dataset where the teacher worked as an environmental consultant in the past and due to her professional background she avidly believed in making students aware of the contemporary issues that impact society and life around them. This is in contrast to one of the teachers interviewed by Ryder and Banner (2013) who considered himself as a scientist due to his background and maintained a stance that science education should only focus on the teaching of canonical facts, so he did not enjoy the teaching of SSIs. The difference lies in the kinds of experiences in their biography. This stimulates the need for more in detail studies from teachers' perspective where instances from teachers' biography are considered, and their rationales for various decisions are studied. The second teacher began teaching SSIs gradually over the course of her teaching career, as she increasingly became interested in the ethical and moral aspects of SSIs. This inclination towards SSIs was also partly triggered by a personal incidence, where she felt the importance of "human aspects" of science while volunteering to help disabled children. The other two teachers were inclined towards teaching SSIs as they were motivated by certain beliefs that were not particularly related to science. These beliefs included the care for the environment and religious beliefs.

Ekborg et al. (2013) conducted a study with an aim to investigate science teachers' choice of content and organisation of work when teaching SSIs. The study further aimed to investigate teachers' understanding of SSIs and its implication on their choice of content and teaching approach. The study was conducted with 55 science teachers from 22 Swedish schools. Teachers in this study, like most of the teachers in previously discussed studies, considered SSIs important for engaging students in science education. They even displayed comfort in conducting group activities with students, which is a problem for many teachers in other studies, e.g., (Anagün and Özden, 2010, Bryce and Gray, 2004, Gray and Bryce, 2006, Lee et al., 2006). However, researchers observed that the teachers had difficulty thinking beyond the confines of canonical facts transmission for teaching science in classrooms. In accordance with the findings of Lee et al. (2006), teachers could not find a way for evaluating students and encouraging analytical consideration of scientific arguments, including moral and ethical values. An interesting observation in the beliefs of teachers while conducting SSIs-oriented discussions was the teachers preconceived notions about right or "good" (p. 16) questions and answers from students. This depicts the teachers' need to maintain control in the classroom. A discussion beyond what is considered right or good by the teachers might lead to an uncomfortable zone from a teacher's standpoint where teachers are no longer fully in control either in terms of discipline or the subject content (Day and Bryce, 2011, McIlmoyle, 2010).

2.2. Strategies and associated rationales for teaching SSIs

This section explores the methods and strategies that teachers use to teach SSIs and teachers' rationales for using these methods and strategies. The studies that are included in this section show different approaches that either teachers use to teach SSIs or consider should be used to teach SSIs e.g. interdisciplinary approach, different methods like discussion, debates, role playing etc., variation in the teachers' views about using the above stated methods and their rationales behind it. This section is further divided into three subsections: the first sub-section examines the studies that researched different models for teaching SSIs and have conceptualised the teaching strategies. The second sub-section includes more descriptive and empirical studies on different strategies and rationales used

by teachers to teach SSIs. The third sub-section focuses on the teaching of SSIs through argumentationskills.

2.2.1. Conceptual frameworks

The research included in this section conceptualised the strategies by breaking down them in term of the focus, learning environment, objectives, teachers' role and the change of trend witnessed in the teaching ofSSIs. Day and Bryce (2011) used a case study approach to characterise the conceptual models of discussion that science teachers use to teach SSIs in comparison to that of humanities teacher. For this purpose, they conducted semi-structured interviews with 18 Scottish teachers (12 science teachers and 6 humanities teachers). In the context of this study, the term discussion was used to describe a broad range of classroom discourses that includes debate, conversation, dialogue, argument and so forth. In the light of the reflection on the interviews, five models of discussion were revealed. I have tried to represent the different models of discussion in Table 2.2. The table marks the difference between the five different models of discussion based on the role of the teacher, learning objectives and the key features of discussion.

Day and Bryce (2011) suggested that these models form a developmental progression where the teacher-mediated discussion acts as a starting point for the students' development of social skills. In parallel to this, the teachers should gradually lose the control over the discussion so as to make it more open and student-centred. However, such a transition in the classroom discussions is not easy. The discussion on socio-scientific issues is usually contentious in nature. Hence, there is always a tendency of the discussion turning into an argument and teacher losing the control over the proceedings of the classroom. Day and Bryce (2011) clearly stated that a paradigm shift is required in science teachers' thinking about their role as science teachers, the way in which they view the changes in the aims of science education and scientific literacy. However, it is often noticed that introduction of new pedagogical methods or a change in the instructional manner is often resisted by the teachers (Zeidler et al., 2011).

Zeidler et al. (2011) initiated a longitudinal study with a high school anatomy and a physiology teacher who was interested in exploring the intersections of SSIs, NOS and the teaching of science content. The aim of this study was to explore the problems and challenges involved in implementing a SSI-driven curriculum in a classroom. For this purpose, they conducted the study in a high school in Florida for a full academic year involving the students of eleventh and twelfth grade (ages 16–18). This gave an opportunity to *"the teachers to observe and monitor growth in students' perspectives of characteristics of science, scientific inquiry, and the relevance of science to daily decision—making through debates, argumentation, class discussions, small group and individual projects"* (p. 284). This study focused on the pedagogical practice of SSI. The authors consider that there is a need for a 'transformative mind-shift' on the behalf of the teachers to deepen their understanding about the distinction between traditional classroom practice and SSI framework which revives the role of a teacher. Figure 2.1 signifies the contrast between how authors have represented the two different mind-sets of how the authors think about science education and science teaching.

Table 2.2: Characteristics of Discussion Models (adapted from Day and Bryce (2011))

Characteristics	Teacher mediated discourse	Open ended inquiry	Development of reasoning skills	Mediated transfer of knowledge to real life	Practice for Democratic Citizens
Role of	**Moderator**	**Participant/ Learner**	**Devil's advocate**	**Guide**	**Facilitator**
Learning objectives	• Predetermined learning objective • To generate multiple responses from students • Enhance/allowing students, engagement with the issue	• Enhance students' skills to articulate their opinions in an open-ended inquiry discussion • To foster an open-minded approach to consider all the pros and cons of the issue without any personal bias.	• To enhance the students reasoning skills by challenging their thinking • To allow them to reflect on their opinion • To develop their listening skills and building their confidence	• To make connections between the science knowledge learned in the schools to the real life situations • To prepare the students for real life situations • To develop higher- order thinking skills	• Thrust of discussion is to develop the skills of discussion i.e. listening skills, communication skills, turn-taking, allow others to express their opinions
Features of discussion	• Teacher mediated higher order questioning is utilised • Teacher clarifies the students' opinion by rephrasing their answers and hence maintains the flow of discussion.	• Not meant to evaluate student's response • Comprises of no right or wrong answers • Often turns out to be argumentative due to the controversial nature of the topics discussed • Students are expected to interpret all the evidences	• Teacher uses critical questioning to challenge students' opinions • There are no specific answers and is hence unpredictable, which may further lead to a loss of control over the direction of discussion	• Discussion is focused on the use of learnt knowledge • Requires students to develop social and interpersonal skills to apply the learnt scientific knowledge in real life contexts	• Discussion is focused on practicing the process of discussion for developing communication and listening skills • Learning outcome is the development of discussion skills

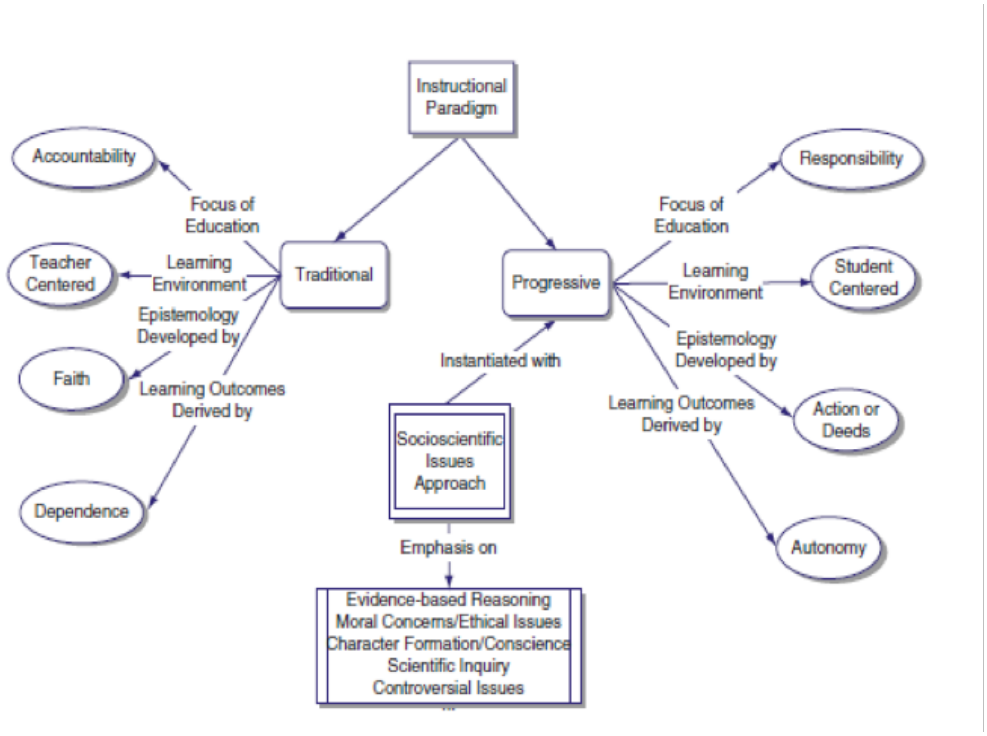


Figure 2.1. Zeidler's Framework. (Zeidler et al., 2011)

Zeidler et al. (2011) intentionally focused their study on observations by the teacher as they wish to relate it to pedagogical practice of SSI. The authors gave a subtle snapshot of the teachers' challenges, teachers' responsibilities, development of teacher training programs and required pedagogical skills to teach SSI. The foremost challenge noted here was to provide students with opportunities and experiences within theclassroom environment, which do not refute their beliefs but allow them to gradually formulate new beliefs through different perspectives. This will also assist the students to understand how scientific concepts are related to 'real-world circumstances' (p. 301). The authors articulated that this would allow the teacher to follow different strategies like debates or discussion-focused activities, discursive activities etc. This will help in making the teacher more "*familiar with epistemological factors of students' reasoning including possible scientific misconceptions, moral reasoning, the ability to interpret and evaluate data, and fallacious reasoning*" (p. 299). However, in using these techniques it is important for a teacher to possess the

fundamental skills and leadership qualities to lead a discussion or a debate confidently.

Zeidler et al. (2011) reiterate in their article that proposing innovative pedagogy is a challenging to the teachers as it compels a teacher to abandon the traditional method of teaching science (through lectures and laboratory investigations) and discover a new transformed role of a teacher (of a mediator or a moderator). The transformation requires the teacher to take a progressive stance and redefine their role as a teacher. Here, the approach will become student-centred rather than teacher-centred and the focus will be to assist the students to develop argumentative skills and analyse and evaluate the evidence available. Given the complexity of this job and mediating factors like confidence and leadership qualities affecting the teaching, the authors highlighted that there is a need to develop a teacher training program that focuses *"on the pedagogical techniques necessary to create content specific and NOS-embedded learning activities that emphasise discourse and debate"* (p. 298). They also commented that the teachers who use debates and discussion for teaching SSIs should refer to previous research in learning how to follow various lines of questioning which will further assist in directing classroom debates. By undergoing this transformation, teachers will perpetually *"become competent in areas of critical thinking, argument quality assessment, and discussing moral dilemmas"* (p. 301).

In an attempt to propose a model for teaching SSIs, Levinson interviewed 83 teachers across England and Wales (Levinson, 2006a, Levinson, 2007). The purpose of the interviews was to know how teachers approach the teaching of SSIs, their previous experiences of teaching SSIs, and the related opportunities and impediments the teachers face while teaching SSIs. In his research, he found that the teachers had few resources they could use to teach SSIs. The paper also highlighted that providing the teachers with facts and information is not enough. Since teachers have varied views, they reflected a need to be assured that the facts provided are accurate. This acceptance of a fact depends on the teachers' interpretations of fact based on their own presuppositions. This was reflected in an excerpt by a teacher where she admitted that "It is difficult for teachers to use newspapers because they need facts not someone's opinion". (Levinson, 2007, p.132).

Table 2.3. Levinson's Model. (Levinson, 2007)

Categories of reasonable disagreement [McLaughlin (2003)]
• Where insufficient evidence is as yet available to settle a matter, but where such evidence could in principle be forthcoming at some point • Where evidence relevant to settling a matter is conflicting, complex and difficult to assess • Where the range of criteria relevant for judging a matter are agreed, but the relevant weight to be given to different criteria in a given decision is disputed • Where a range of cherished goods cannot simultaneously be realized, and where there is a lack of a clear answer about the grounds on which priorities can be set and adjustments made • Where the range of criteria relevant for judging a matter are broadly agreed, but there is dispute about the proper interpretation of a criterion or criteria, given the indeterminacy of many concepts • Where there are different kinds of normative consideration of different force on both sides of an issue, and it is hard to make an overall judgement • Where there is disagreement about the criteria relevant for judgement • Where the differing 'total experiences' of people in the course of their lives shapes their judgements in divergent ways • Where there is no agreement about whole frameworks of understanding relevant for judgement
Communicative virtues when conducting a discussion with conflicting views
• Patience • Tolerance • Respect for differences • Attentive and thoughtful listening • Openness • Honest self-expression • Adherence to agreed procedures • Freedom of expression • Equality
Modes of thought
• Narrative mode which involves the voices of the participants, and for lay people in socio-scientific issues the substantive science is often reconstructed, marginalized or inert. • Logico-scientific mode based on scientific evidence.

This highlights that the teachers have their own perception of what they considered as an accurate piece of evidence that can be used for teaching SSIs. This perspective is in resemblance with the findings of (Zeidler et al., 2011), however (Zeidler et al., 2011) advocated that it is the teachers who need to be vigilant enough to find reliable as well as unreliable sources of data which will allow the student to support their thoughts and also learn how to critically validate a source of knowledge. For this (Zeidler et al., 2011) suggested a need to develop a teacher training program and Levinson (2006a) reasoned a need to provide teachers with a model of how these evidences can be used to teach SSIs. Levinson's model (Levinson, 2006a, Levinson, 2006b, Levinson, 2007) was informed by (McLaughlin, 2003) categories of reasonable disagreement (See Table 2.3). The reasonable disagreement refers to the "*an account of the sources, or causes, of disagreement between reasonable persons*" (Rawls, 1993) (cited in Levinson (2007)). He believed that while teaching SSIs, there are high chances that teachers are left either with no proper solution to a controversial SSI or are unable to explicitly reason out the intricacies of disagreement to the students. Levinson attempted to objectify the first two categories of disagreement in relation to the teachers' perception about the role of evidence in teaching controversial SSIs. He concluded his paper with an idea that such a model will help the teacher to focus on certain aspects of controversy where they can give a fair attempt to exemplify to students the different areas of disagreement of a SSI. Through this model, the teachers can explicate that since SSIs come under the umbrella of changing and challenging zone. Hence, showing the students varied disputed ideas related to a SSI.

As an extension to the above work, Levinson (2006b) further adapted McLaughlin (2003) categories of reasonable disagreement and again emphasised the need for a theoretical framework for teaching controversial socio-scientific issues in classrooms. He explains an approach for this framework based on three categories: categories of reasonable disagreement, the communicative virtues, and modes of thought. According to Levinson to underpin any disagreement amongst students, teachers can use the categories of different types of reasonable disagreements, and the communicative virtues like respect, freedom, openness etc. He also suggested that the various communicative virtues should be chosen according to the type of discussion, because not every disposition fits every discussion. In modes of thought

two different modes are defined, the first one being the Logico-scientific mode, which is based on the empirical evidence or scientific reasoning, which has concrete evidence. The second mode is the narrative mode, which represents the voice of the participants. It helps people to relate to others' opinion and to come across experiences of others that are not yet known to people. The author explains with an example that the topics where heated arguments are expected can be handled by narrative mode by teachers, by emphasizing respect for everyone's views and can help in bringing forward the experiences of students without necessarily reaching a conclusion. In both the attempts the author (Levinson, 2006a, Levinson, 2006b) tried to work on how SSIs can be taught in the schools. His basic argument was driven by the idea that "the place of controversy in the science curriculum has been clouded with uncertainty because of the lack of clarity about the epistemological and ethical structure of controversy" (Levinson, 2006b)(p. 1203). Here he has tried to relate his thoughts by proposing methods like open discussions and narrative (story telling technique) for teaching SSIs.

Extending this work, Levinson (2008) suggested that personal narratives can be used to teach socio-scientific issues. He proposed a way in which narratives can be constructed within a SSI. For enhancing the objectivity, SSIs can be taught through multiple perspectives. He tries to explain it with an example that a worker from a nuclear power plant might have a different outlook towards the controversy, as they will talk about their work, their position and their reaction to the disagreement. However, another person who wishes to stop the functioning of a nuclear power plant may have a completely different perspective. This kind of teaching method helps the teachers to express the real picture of two different a n d challenging perspectives. He suggested that narratives represent the cognitive, moral and emotional aspects of a controversial SSI. This gives the students a chance to reconsider all the different aspects of the complex nature of SSIs and then the students can express their own personal viewpoints. Understanding this complexity of SSIs may also require teachers to have some understanding of probability and risk. This point was raised by Levinson et al. (2011) who developed the principles for pedagogy of risk in socio-scientific issues. In pursuit of this aim, the authors built a set of software tools based on the analysis of the knowledge of risk and from the views reflected in the discussions based on why teachers consider teaching and learning of

risk. The motive of this software was to provide teachers with a realistic situation in which they will take decisions, think about the factors that affect their decision and redraft the repercussions of their decision. For this purpose, they appointed three pairs of teachers (one mathematics and one science teacher in each pair) who worked together. The analysis of the data was done inductively based on the audio and video recordings, observational notes and the final notes of the participants stating the reason behind their final decision. The authors concluded that risk is a multi-disciplinary subject and also contains epistemic and non-epistemic values. Hence, it is termed as multi-dimensional and different dimensions of risk can be recognised by discussing contextualised socio-scientific quandaries. The models such as the model used in the study by Levinson et al. (2011) helps in eliciting the discussions about socio-scientific issues by explicating the different dimensions involved in that issue. Along with this, more assessment tools can be designed that can further help in the analysis of the multi-dimensional nature of the risk.

Along with the development of new tools and models, Gardner and Jones (2011) show that the instructional frames used by Graduate Teaching Assistants (GTAs) can be focused on (1) Science as authority where the focus was on just scientific contents of the class without much room for open discussion, thus potential controversy, (2) Community as authority where the focus was on mass consensus. They gave weight to the consensus gained by discussion amongst students as the solution to the controversial aspects of topic, (3) Individual as authority where the evidence-based arguments were supported even though they were contrasting amongst students. "*Instead of modelling community decision-making and consensus building, they (GTAs) asked students to reflect on their own opinions and situations as if it were necessary for them to make personal decisions regarding a particular controversial issue*" (p. 1044).

2.2.2. Empirical studies on strategies and associated rationales used for teaching SSIs

It has been described in previous section that teachers have different views about the teaching of SSIs. The views that they hold affect their choice of the teaching methods. It has been observed before by Sadler et al. (2006) that there are teachers who considered that it is a responsibility of a science teacher to prepare the students to think critically and take informed decisions based on the scientific evidence. On the contrary, there were science teachers who considered that science is a "value-free" subject and their role is to deliver scientific 'facts' to the students and not deal with controversial ethical or social issues (Levinson et al., 2001, Sadler et al., 2006). This section will explore different empirical studies that have sought to explore the different methods and strategies teachers use to teach SSIs.

Levinson et al. (2001) carried out a study with the teachers across England and Wales to investigate the extent to which teachers were involved with the teaching of controversial bioscience issues and the institutional factors faced by them. They found that almost 60% of teachers thought that the coverage of the controversial biomedical issues was very less. Although majority of the teachers strongly agreed that students should be provided with an opportunity to explore biomedical socio-scientific issues in the class, they rarely taught those issues in the classroom. They found that humanities teachers were found to be more confident when covering ethical or social issues. The humanities teacher felt that they had the experience and the expertise to carry out such discussions in the class; however, they had their reservations because of their limited scientific knowledge. Levinson et al. (2001) suggested that both humanities and science teachers should work together to learn about different pedagogical approaches. They also suggested that special training courses should be introduced for prospective science teachers to provide them with necessary skills and opportunities "in the area of initiating and managing discussions" (p. 21).

This was further reflected in Levinson (2006a) who highlighted the complex relationship between how teachers of different subjects view a need of

reliable information or evidence for teaching SSIs, how science knowledge can be used to teach SSIs and underlying social and political constraints and the contrast between facts and opinions (discussed further in next section). He focused this piece of research on teachers' perceptions of the role of evidence in teaching controversial socio-scientific issues. It was revealed through the interviews that a history teacher holds invariant views regarding SSIs and was not at all bothered about science behind the SSIs. She said, *"What I perceive my job to be is to (...) look at the moral issues behind the holocaust. The chemical composition of (...) makes no difference whatsoever"* (p. 140). The teacher also expressed her uneasiness in understanding the way science is represented in SSIs. The teacher commented *"If there are scientific facts I would want them simple enough so that even I could understand it"* (p. 140). On the contrary biology teacher showed her reluctance towards discussing values and preferred teaching scientific knowledge more.

Oulton et al. (2004a) focused their study to explore teachers' attitudes and practices related to teaching controversial issues across the curriculum in England. (Topics like GM crops, drugs, environmental issues, evolution etc., which are SSIs, were also addressed in this study). From the response of 205 surveyed questionnaires, majority of teachers claimed that the guidance provided by National Curriculum in how to handle controversial issues is not explicit and the teachers also lack a formal training to teach controversial issues. Hence, the teachers are inconsistent in the choice of teaching strategies they use for teaching these issues. Teachers further disclosed that in an ideal situation they would have preferred to use discussions, role-play and a wide range of resources like Internet, videos etc. to teach controversial issues. However, they were constrained by different factors that are further discussed in section 3. Discussions, role-playing activities and debates were also considered as an opportunity by Profile-A and Profile-B teachers (see Table 2.1) in study by Sadler et al. (2006), where the students were exposed to multiple perspectives and were challenged with contradictory perspectives.

Using discussion for teaching controversial issues was also highlighted in the study by Hand and Levinson (2012). They stated in their study *"discussion is peculiarly conducive to appreciative understanding of the different positions in a controversy and to empathise with those who hold them (...) it is not just that*

discussion yields the most appreciative understanding of controversial issues, but that controversial issues afford the most promising opportunities for engaging students in discussion" (p. 616). Hence, to identify the factors that affects the discussion of POS in the class. Hand and Levinson (2012) conducted an empirical study on some innovative aspects of AS level course Perspectives on Science (POS). They used a mixed method research design involving survey questionnaires, semi-structured interviews and classroom observations of students as well as teachers across 26 secondary schools and further education colleges in UK. They further addressed in their study that discussions help the students in engaging with their thoughts concretely. This was considered a more comprehensive way than reading through textbooks and understanding controversial issues in a lecture. Some of the topics discussed in the classroom included xenotransplantation, organ donation and genetic engineering. Furthermore, teachers vehemently agreed that if the students had strong, extreme or diverse views regarding a topic, then the discussions were more interesting and dynamic in contrast to those where teachers appoint students to defend a particular view irrespective of the fact whether the students believe it or not. Hand and Levinson (2012) discerned from this study that discussion of controversial issues can be substantially refined when students are equipped with the skills to analyse and evaluate arguments. Moreover, they also mentioned that for this explicit instruction should be provided to the students before they start the discussion. Van der Zande et al. (2012) conducted a study to assess the expertise of a group of nine experienced teachers in terms of teaching a specific SSI, i.e., genetic testing. Van der Zande et al. (2012) argued that a specific set of expertise is needed to teach a topic like genetic testing. They classified the expertise for teaching genetic testing into four areas: The first one was the level of subject matter expertise that would reflect the knowledge of teachers from the subject textbook standpoint and also the current developments regarding the subject matter. The second level of expertise is the pedagogical content expertise, which signifies the choice of teaching-learning activities considering the students' notions of the subject matter and the level of difficulty to convey the subject matter. The third level of expertise, i.e., interpersonal expertise, points to the ability of teachers to relate to the students and the level of harmony and trust between students and teachers. The fourth level of expertise is the moral expertise, i.e., the way teachers deal with the moral, ethical and values-laden aspects of SSIs. These levels of expertise (especially second to fourth levels), in my opinion, are not specific and restricted to just genetic testing,

and can indeed be used for analysing the teaching of any other SSIs. The mode of data collection was questionnaires, interviews and in-class filming. The teachers were cross-questioned after a filming session to ensure congruence between their views expressed in interviews and actual practices. The analysis was conducted to determine the teachers' expertise in second to fourth aspect discussed above. In terms of pedagogical content expertise, teachers were found to use on an average 11 different teaching-learning activities from a total of 21 activities to teach genetic testing to students. These activities include among others; narratives (stories), teacher-centred activities (lecture method), student-centred (problem-based activities in small groups), and whole class activities such as role-play. The analysis for this level of expertise, however, does not discuss the teachers' rationale and circumstances under which the teachers selected a certain activity.

For interpersonal expertise, teachers' behaviour was classified based on an interpersonal behaviour model suggested by Wubbels et al. (2006). This model includes eight types of interpersonal behaviours, namely, directive, authoritative, tolerant and authoritative, tolerant, uncertain & tolerant, uncertain & aggressive, drudging and repressive. Based on the analysis, eight out of nine teachers were classified as tolerant & authoritative, and only one t e a c h e r as authoritative. In the description of classroom environment of authoritative teachers, Wubbels et al. (2006) explained that the environment is *"well-structured [lessons], pleasant and task-oriented. (...) their [teachers'] favourite method is the lecture; Authoritative teachers frequently use other methods" (p. 12).* On the other hand, the environment in tolerant & authoritative teachers' classrooms is relaxed in comparison and teachers share more closer rapport with students as compared to entirely authoritative teachers. Since, the sampling of teachers was deliberately targeted at only very experienced teachers that had knowledge in genetic testing, hence, authors expected to encounter teachers with such interpersonal behaviour profiles. With respect to the fourth level of expertise (moral expertise), the teachers were assessed based on two different parameters. First, teachers were classified in one of the four approaches discerned by Ritzen (2004) for dealing with values-laden education. This includes value-transfer (transfer of teachers' own values), value clarification (focus on students' values), value-development (premising that students continually develop values), and value communication (teachers contribute to skills students require to

participate). The second aspect is the role assumed by teachers while teaching is such a situation. These roles include, participant, devil's advocate, neutral facilitator, committed instructor, interviewer, observer, and absent leader. In analysis, three teachers were classified as 'absent leader' and the rest were 'committed instructor'. Absent leaders are termed as the teachers that initiate and organise the discussions initially and then withdraw from them. A committed instructor, on the other hand, explains concepts and ideas in a sustained manner and provides viewpoints on controversial aspects. This shows that none of the teachers resorted to absolute value transfer in the analysis. This paper discusses some very important aspects of SSIs teaching and from varied perspectives. However, an important aspect that could have improved the generalisability of the results is considering the impeding or facilitating factors while assessing the teachers' expertise.

2.2.3. Argumentation

In the previous subsections, I examined existing research works that identified the methods and strategies for the teaching of SSIs. This examination resulted in methods, such as discussions and debates that have been employed by teachers for meeting the goals of scientific literacy. An integral part of the scientific literacy goals is the ability to use scientific evidence for decision making on socio-scientific issues. Dawson and Venville (2010) underlines the need for the students to be able to, as a part of decision making, compare alternative solutions, develop a critical eye for and thoroughly evaluate the integrity of scientific claims and evidences. Driver et al. (2000) accentuates argumentation as an effective means to help students achieve above goals. Argumentation is a widely studied topic in the science education literature (Driver et al., 2000), and several authors have provided compelling motives for teaching scientific argumentation in context of SSIs (Evagorou et al., 2012, Jiménez-Aleixandre, 2002, Sadler and Donnelly, 2006). These motives for the teaching of argumentation to students include, among others, develop and verify the scientific knowledge with argumentation, develop conceptual understanding of SSIs and students' ability to talk and defend their understanding of scientific learning, and develop critical outlook, reasoning, and ability to argue in a logical and coherent manner.

The phrase 'argumentation', for a large majority of people, evokes the images of conflict and frenzied discourse between people (Dawson and Venville,2010), however, in context of science teaching Sampson and Clark (2008) define argumentation as a complex process during which students produce certain artefacts (arguments), and coordinate these artefacts with evidences to support or refute a theory (Suppe, 1998).

These artefacts are the claims or conclusions given by students, and backed with a justification or a reason (Kuhn, 1991, Means and Voss, 1996). This process, as explained by Kuhn (1991), does not come naturally to people and needs to be developed with instruction and practice overtime, in particular the art of producing reasonable and valid arguments. For practicing argumentation, students do not just need to learn to present their claims and back it with a justification, most importantly they need to consider multiple accounts or the alternative theories (Driver et al., 2000, Monk and Osborne, 1997). This is particularly relevant to the socio-scientific argumentation, as multiple perspectives and alternate theories are typically concomitant to all SSIs related discussions.

Teaching of argumentation merely by instruction to students has been found to be insufficient for improving the level of students' arguments (Erduran et al., 2004). Instead, the opportunity for the students to practice argumentation along with instruction has been found to produce improvements in the level of argumentation. Many researchers have emphasised the role of teachers in this (Evagorou et al., 2012). The teachers that provide an "environment of confidence which encouraged students to express and defend their opinions" (Jimenez-Aleixandre et al., 2000, p.782) are more likely to achieve improvements in the level of students' argumentation. Simon et al. (2006) assessed the argumentation dialogue in classrooms of 12 teachers that used argumentation for teaching SSIs. They compared the nature and quality of argumentation among the students of these 12 teachers. They concluded from their assessment that teachers play a big role in the development of levels of arguments in students. The teachers that encouraged their students to understand the importance of dialogic discourse and reflection on their claims during argumentation were successful in improving the level of argumentation in students. Further, the researchers identified the pedagogical

practices that are employed by successful teachers. These practices include, among others, teachers define the arguments, provide examples for the arguments, prompt the students to construct arguments and counterarguments, justify their arguments, and listen to others arguments. The findings of Simon et al. (2006) in this study also concur to the findings of the researchers discussed in Section 2.1 where they emphasised the role of teachers' beliefs in the argumentation practice in classrooms.

A number of researchers have used Toulmin's Argumentation Pattern (TAP) (Toulmin, 2003) for assessing the dialogic and written argumentation (Erduran et al., 2004, Zohar and Nemet, 2002), and in some cases also as a reference model for teaching effective argumentation to students and teachers (Sampson and Clark, 2008). TAP focuses on six key elements with which an argument is constructed or analysed: - *claim, data, warrant, backing, qualifiers* and *rebuttal*. The *claim* in the argumentation pattern is the statement or assertion being argued, which is justified by *data* or in other words, the factual evidence. *Warrants* are the logical statements that serve as the link between data and claim, explaining how does the data help prove the claim. *Backings* are the supporting statements to warrants that do not necessarily help prove the claims directly but do strengthen the warrants. *Qualifiers* provide the conditions under which the arguments hold and the strength of the claim. *Rebuttals*, in contrast to qualifiers, provide the conditions under which the claim does not hold or are the counterclaims that invalidated the claims. Kuhn (1991) segregated the concepts of rebuttals and counterclaims, where he defined rebuttals as the arguments against an alternate theory of claims, and counterclaims as the arguments against one's own theory.

Venville and Dawson (2010) used TAP for instructional purposes, and conducted a professional learning session with a biology teacher, who served as a subject for their study. As a part of their study, Venville and Dawson (2010) analysed the argumentation sessions conducted by this teacher with an aim to identify the factors that promoted argumentation in the context of SSIs. They identified four such factors, namely, role of teacher, role of students, the context of SSI under discussion, and the use of writing frames. A further extension of this study with the same teacher was presented in the study byVenville and Dawson (2010), where researchers used an intervention mechanism (over three lessons based on TAP) with students to teach

them about argumentation skills and the application of argumentation skills to SSIs. In this study, the researchers compared the conceptual knowledge of students prior to and after the argumentation intervention and also to a control group that did not participate in the intervention at all. They concluded that the intervention did strengthen the ability of students to produce complex arguments. The intervention, and the participation in the argumentation process during which the teacher helped them model and present sophisticated arguments, enhanced students' content knowledge about the SSIs as well. An important consideration, which is true for many other similar studies as well, is that it is hard to consider these findings outside the particular context of these studies. For example, in these studies the choice of the teacher was significant on the findings; hence, it is difficult to judge the impact of such interventions on students without considering the impact of teachers' pre-existent strong pedagogical skills. This concurs with the findings of Simon et al. (2006) that teachers' pedagogical skills prior to professional learning sessions also play an important role in developing the argumentation skills ofstudents.

Osborne et al. (2004) conducted a long-term intervention for two years to identify the pedagogical strategies necessary for promoting argumentation skills and how implementation of these strategies enhances the quality of students' argumentation. The research took place in two phases. In the first phase 12 science teachers were selected and trained with the necessary argumentation skills. The teachers were provided with practical guidelines to create opportunities for students to engage with competing theories. Thereby, students can make sense of the evidence provided to them, discuss the alternative viewpoints and construct their arguments. This was done through nine argument-based lessons, which included both socio-scientific and scientific issues. For the second phase, six teachers were shortlisted to repeat the teaching of argumentation, which was followed by an interview with the teachers. Osborne et al. (2004) focused their analysis on assessing the quality of the argumentation through Toulmin's Argumentation Pattern (TAP). The aim was to identify the components of TAP i.e. claim, data, warrants, backings, qualifiers and rebuttals. However, certain limitations were recognised by Osborne et al. (2004). The authors found it difficult to identify the difference between the data, warrants and backings. Hence, they merged these three elements into a single element and termed it as "grounds". Similar challenge was

recognised by (Forman et al., 1998, Jiménez-Aleixandre, 2002, Sampson and Clark, 2008) while distinguishing claims, data, warrants and backings as individual components from students' arguments. Evagorou et al., (2012) and Sampson and Clark, (2008) further highlighted another limitation of TAP, that it does not consider the validity of the scientific knowledge in the students' arguments because of which one cannot clearly tell apart the quality of two arguments, when the arguments comprise of same TAP components (such as, claims, data, warrants, and rebuttals). Keeping in mind the limitations of TAP, Osborne et al. (2004) proposed a framework with five reference levels of arguments to address such a situation where one needs to assess the quality of argumentation, in more depth than TAP. These five levels are as follows: -

- Level 1 arguments are the ones that are simple claims against a counter-claim, or a claim against a claim;
- Level 2 arguments are the claims against claims with either data, warrants or backings but do not have rebuttals;
- Level 3 arguments are a series of claims/counterclaims and that in addition to the contents of level 2 arguments have a weak rebuttal;
- Level 4 arguments have several claims/counterclaims with a definite rebuttal;
- Level 5 arguments are the ones that have multiple rebuttals in addition to the level 4 argument contents;

The above hierarchy of argumentation structure accentuates the incorporation of rebuttals in the arguments as a criterion for producing a high-level or a high-quality argument. They considered rebuts as an opportunity to challenge an individual's underlying beliefs. Furthermore, alternative theories proposed through rebuttals have a potential to question the grounds provided by the participant as a justification of their claim. One of their initial findings was that since teachers' had varied understanding of what accounts for an argument, their emphasis on teaching of argumentation also varied. Higher level of arguments was observed in socio-scientific contexts as compared to scientific contexts. The authors suggested that students were able to correlate their real- life experiences with socio-scientific topic. This increased familiarity helped the students to engage more with

the topic and helped them in providing reasonable evidences and justifications. It was also found that teaching of argumentation increased the quality of students' arguments in the classroom. However, this increase was not a significant change. The authors suggested that skills of argumentation are not naturally occurring; these skills need to be enhanced through continuous practice in the classrooms.

2.3. Factors affecting the teaching of SSIs

The review presented in Section 2.1 showed that whilst there are varied perspectives of teachers about SSIs and the teaching of SSIs, most teachers are broadly supportive of the idea of including SSIs in the science curriculum. Of these, only a few teachers are actually comfortable in teaching SSIs (Day and Bryce, 2011), whereas a significant number of science teachers do not teach SSIs in practice (Bartholomew et al., 2004, Bryce and Gray, 2004, Gray and Bryce, 2006, Zeidler and Keefer, 2003). As discussed in Section 2.1, there are a number of contextual factors that impact the teaching of SSIs. In order to increase the percentage of teachers that implement SSIs in practice, one needs to further investigate into the factors that impel teachers for not implementing SSIs (Lee et al., 2006, Sadler et al., 2006). The recent trends in research community on teaching of SSIs have highlighted different factors like teachers own personal views and values, their pedagogical skills, time constraints, lack of guidance, lack of expertise in handling debates, ethical quandaries and many other personal variations that have made teaching of SSIs quite challenging (Cotton, 2006, Gardner and Jones, 2011, Lee and Witz, 2009). This section discusses different strands of research that have studied these factors.

Several research studies provide a list of factors that impact the teaching of SSIs, e.g., Ryder (2015). Alternatively, there are evidences of the factors influencing the teaching of SSIs within the excerpts of the teachers' interviews in different research papers. Goodson (2003) provided a classification of such influencing factors that was further corroborated by Ryder (2015), Ryder and Banner (2013), in the context of implementation of education reforms. The classification of factors includes three categories, namely, *Personal, Internal* and *External*. *Personal* factors are specific to a teacher (teaching SSIs), e.g., their beliefs,

pedagogical skills or subject matter knowledge; Internal factors are related to the school or the subject department of the teacher, e.g., the school or department leadership, school's priorities or ethos; and *External* refers to the factors that originate from outside the confines of the school, e.g., national reforms and assessment system. These strands of research specifically focused on the analysis of factors that facilitate or hinder the implementation of educational reforms. However, the factors delineated in these studies and the aforementioned classification has a significant overlap with the factors that influence the teaching of SSIs. This can also be explained by the fact that most recent science education reforms partly or fully aim at implementing SSIs oriented teaching.

Table 2.4 lists various factors found in the literature that impact the teaching of SSIs and the studies where they have been highlighted. These factors have been categorised into personal, internal, and external factors. Only those studies have been mentioned as the source where a substantial level of impact for a given factor has been discussed. These factors have been tabulated based on my review of the literature. Some of the factors and the impact of them on teaching of SSIs are discussed in detail further on.

Table 2.4. Factors influencing the teaching of SSIs and research works indicating the impact of the given factors.

	Personal Factors	**Literature**
PF1	Subject knowledge	(Albe et al., 2014, Bartholomew et al., 2004, Ryder and Banner, 2013)
PF2	Pedagogical skills	(Albe et al., 2014, Bartholomew et al., 2004, Levinson et al., 2001, Ryder and Banner, 2013)
PF3	Teachers' professional and personal biography	(Albe et al., 2014, Barrett and Nieswandt, 2010, Ryder and Banner, 2013)

PF4	Teachers' beliefs about the purposes of science education	(Albe et al., 2014, Barrett and Nieswandt, 2010, Bartholomew et al., 2004, Hansen and Olson, 1996, Jenkins, 1992, Lee and Witz, 2009, Levinson et al., 2001, Ryder and Banner, 2013, Sadler et al., 2006, Van der Zande et al., 2012)
PF5	Teachers' self-efficacy beliefs	(Lee et al., 2006, Sadler et al., 2006)
PF6	Perceived audiences	(Ekborg et al., 2010, Lee et al., 2006, Van der Zande et al., 2012)
PF7	Teachers' personal dilemmas	(Lee et al., 2006)
PF8	Teachers' experience Level	(Albe et al., 2014, Gardner and Jones, 2011, Reis and Galvão, 2009)
PF9	Teachers' value position on particular issues	(Barrett and Nieswandt, 2010, Lee et al., 2006)
	Internal Factors	**Literature**
IF1	Availability of teaching resources	(Ekborg et al., 2010, Lee et al., 2006, Sadler et al., 2006)
IF2	Collaboration among teachers	(Ekborg et al., 2010)
IF3	School Leadership	(Ekborg et al., 2010, Sadler et al., 2006)
IF4	Trainings and Workshops (Professional development activities)	(Bryce and Gray, 2004, Reis and Galvão, 2009, Lee et al., 2006)
IF5	Time and curriculum pressures	(Barrett and Nieswandt, 2010, Lee et al., 2006, Oulton et al., 2004a, Reis and Galvão, 2009, Sadler et al., 2006)
IF6	Classroom strength (Number of students per class)	(Lee et al., 2006)
	External Factors	**Literature**
EF1	National curriculum frameworks	(Bryce and Gray, 2004, Ekborg et al., 2010, Lee et al., 2006)
EF2	Parental pressure	(Lee et al., 2006, Sadler et al., 2006)
EF3	National level or external examination	(Ekborg et al., 2010, Ryder and Banner, 2013, Lee et al., 2006, Sadler et al., 2006)

EF4	Cultural aspects (e.g., the focus on or the inhibition to teach specific topics)	(Lee et al., 2006)

2.3.1. Personal Context

A majority of personal factors are related to teachers' views, such as their views on the purpose of science education, importance of SSIs in science curriculum, and their own role as a science teacher. This has a significant overlap with the content and the literature already reviewed in Section 2.1 on teachers' perspective. Hence, in this section I only discuss the personal factors that are distinct from the points already discussed in Section 2.1.

Lee et al. (2006) delineated three categories of factors that influence the teaching of SSIs after exploring perception of 86 science teachers about SSIs. The three categories being teacher-related, curriculum-related and cultural factors. The teacher-related factors are the personal factors related to the teachers' personality, beliefs and pedagogical skills. Teacher-related factors are a direct overlap to the personal factors delineated by Goodson (2003). The curriculum-related factors refer to the factors that are related to the curriculum coverage, and the material required for teaching SSIs. The cultural factors are related to the school culture in Korea, and other related factors such as the pressure from parents. The teacher-related or personal factors have been discussed below in this subsection, and curriculum and culture factors in internal and external factors in subsections 2.3.2. and 2.3.3.

One of the most prevalent factor, in terms of being discussed by the teachers, in Lee et al. (2006) study was the teachers' self-efficacy beliefs. The self-efficacy doubts of teachers are twofold. First, the teachers doubted their pedagogical skills to teach SSIs and secondly, the teachers were unsure about their own stance on SSIs. For pedagogical skills, teachers felt that they are incompetent and under-trained to handle multiple-perspectives laden interactive activities with students to teach SSIs. Teachers' pedagogical skills play a significant role in their self-efficacy

beliefs and in turn impact their teaching in practice (Ramey-Gassert and Shroyer, 1992). A common perception among teachers, mirrored in several studies on SSIs teaching, is that the teachers believe that they lack the required skills to seamlessly integrate the dynamic discussions on SSIs with the static teaching of content knowledge (Anagün and Özden, 2010, Lee et al., 2006, Sadler et al., 2006). The quandaries of teachers are primarily due to the lack of skills to address ethical and moral dimensions of SSIs, inability to assess students on these dimensions, and inability to manage classroom discussions with multiple perspectives. Consequently, teachers find it difficult to implement any instructional approach for teaching SSIs or to evaluate the students on the different dimensions of SSIs (Lee et al., 2006). A very similar pattern in teachers' competency perceptions was witnessed in Anagün and Özden (2010) study, where teachers believed they lack the necessary skills to teach SSIs. However, interestingly both researchers and teachers in Anagün and Özden (2010) study believed that at the core of what seems like a very personal factor is actually an external factor. The lack of focus on SSIs in teacher education development programs in Turkey, according to them is the primary reason behind teachers' incompetency beliefs. *"The basic reason why teacher candidates consider themselves as incompetent is the [education] program."* (p. 985). Bosser et al. (2015) conducted a year-long study with two science teachers to understand the challenges faced by teachers when including SSIs as core elements of science education as a part of a curriculum reform. Over the year of this study, researchers were in constant contact with two teachers to reflect upon their experiences and challenges while teaching SSIs. Teachers were facilitated by a mentor, with whom they could communicate any intermittent challenges faced and seek solutions for those challenges. One of the primary challenges reflected in this study to the teaching of SSIs is the inability of teachers to include SSIs as core elements in science teaching due to lack of appropriate pedagogical skills. They were unable to design activities that would cover various aspects of teaching SSIs. During execution of activities, teachers were unable to share clearly the envisioned learning goals with the students, which prevented the shift of focus of students towards new learning goals. The second facet of the teachers' self-efficacy doubts is related to their insecurity about their own position and critical analyses on SSIs (Lee et al., 2006). Cross and Price (1996) discovered in their study that teachers had fundamental problems in tackling SSIs-teaching because of their own value positions on SSIs. Teachers further showed reluctance in teaching of interdisciplinary SSIs as they felt they are outside their

expertise zone while discussing SSIs, and they would rather focus on their own areas of expertise, i.e., teaching canonical facts (Gayford, 2002, Oulton et al., 2004b, Reis and Galvão, 2004a). Researchers suggest professional development programs addressing both the facets of self-efficacy doubts, i.e., firstly, educational programs for developing pedagogical skills required for teaching SSIs, and secondly, opportunities for teachers to help them reflect back on their positions on the importance of SSIs and moral-ethical aspects for specific issues (Sadler et al., 2006, Reis and Galvão, 2004a).

Teachers' notion of the purpose of science education is also an important factor that influences teachers' implementation of the SSIs into their teaching. I have discussed the views of certain teachers in Section2.1that did not consider science as a value-laden subject or gave any importance to moral and ethics in the space of science teaching. On the other hand, there were also certain other teachers that were personally motivated to teach SSIs. A variation of such personal motives of teachers that drove them to teach SSIs was witnessed in studies (Lee et al., 2006, Reis and Galvão, 2009). Reis and Galvão (2009) conducted a study with an experienced Biology and Geology teacher to understand the factors that positively influence or facilitate the teaching of SSIs. The teacher was interviewed and observed in her classrooms (11th grade) over an academic year in Portugal. The teacher was selected for this study because of her experience and avid passion for teaching SSIs. She displayed strong beliefs about the importance of analysis and understanding of scientific concepts for students. She constantly tried to connect science lessons to everyday lives of students. The level of her content knowledge and pedagogical skills for handling discussions targeted at SSIs helped her to address any factors that posed obstacles to her teaching. The primary stimulant behind her preference to teach SSIs was her belief about the purpose of science education and her role as a science teacher, i.e., to make students aware of all aspects of science, including moral and ethical. In Lee et al. (2006) study certain teachers did cover specific SSIs in their classrooms. However, they did so because of the value proposition teachers associated to these issues. They covered only those topics that they felt were relevant to Korean context and were avidly covered in media. They believed that this would help their students become aware of the events around them. These topics included, among others, human cloning and environmental issues.

Another personal factor delineated by Lee et al. (2006) is the perception of teachers about the students. The perceived previous knowledge of the students, the perceived likes and dislikes of the audience might influence the teaching of SSIs. In Lee et al.'s (2006) study one of the teachers addressed human cloning issue as she believed this would be interesting for students and they would have some background knowledge about it from fictional books and movies. Another influence of teachers' perceptions about students was witnessed in Ekborg et al. (2010) study, in two different forms. First, the perception of teachers about the expected outlook of students towards SSIs teaching impacted their teaching, and second, the perceived previous knowledge of students impacted their teaching. In first case, teachers expected their students to be proactive in the SSIs activities and explore relevant questions and answers on their own. As a result, teachers limited their role to more of a spectator in these activities and held back while students searched or discussed the answers on their own. This was also an outcome of the teachers' perceived notion of 'freedom' that students should be given during interactive SSIs teaching activities. In the second case, certain teachers believed that their students are not mature enough to handle such discussions on their own and do not have appropriate content knowledge or argumentation skills. Hence, they decided to support the activities. In a complete contrast to the teachers' reaction to the second case in Lee et al. (2006) study, a few teachers did not teach SSIs as they believed their students are not mature enough to handle SSIs discussions and probably are not even interested in such discussions. Consequently, the teachers refrained from teaching SSIs.

Lee et al. (2006) identified a dilemma of teachers that influenced their SSIs teaching. The teachers felt that they might influence students with their own personal perceptions about SSIs. The teachers expressed a need to maintain a neutral stance during all SSIs-related activities, but believed it was difficult to remain neutral when discussing controversial topics with students (Anagün and Özden, 2010, Barrett, 2008, Cotton, 2006, Topcu et al., 2010). On a similar note, teachers in Lee et al. (2006) study mentioned their desire to remain neutral but felt that they would retract to their own personal views in practice. The teachers further feared that students would grasp teachers' (biased) views during such discussions. Such beliefs of teachers reflect the inherent tension in teachers' mind between

teaching controversial issues and teaching value-free science content. There is a need for a shift in the mental outlook of teachers from traditional science teaching, where students would easily grasp whatever factual content they would teach in the classroom, to a more SSIs oriented teaching with moral and ethical considerations, where it is hard for students to just simply grasp whatever their teachers' views are.

Another significant personal factor is the amount of teaching experience. The entry-level or novice teachers often have difficulties in addressing multiple aspects of SSIs curriculum as they usually spend excessive amount of time in adjusting to the school and teaching environment (Cotton, 2006, Gardner and Jones, 2011, Lee and Witz, 2009). The experienced teachers, on the other hand, are more used to the environment and curriculum and have relatively more time to develop skills for and implement interactive activities (Reis and Galvão, 2004a). The teacher reported in Reis and Galvão (2004a) study adapted the curriculum for each class depending on their needs to cover SSIs based on her experiences. Day and Bryce (2011) also complemented this finding with their results on use of discussions for teaching SSIs. They found substantial difference between the emphases the experienced science teachers place on discussions for students' exposure to multiple perspectives of SSIs, as compared to the newly qualified science teachers. Most of the teachers from the research works I reviewed in my thesis, e.g., Reis and Galvão (2004a) and Lee and Witz (2009) that were found to be comfortable with teaching of SSIs and did so in practice were actually having substantial experience in science teaching. However, in contrast to this, Albe et al. (2014) asserted that the implementation of SSIs discussion activities is not exclusive to the experienced teachers. According to Albe et al. (2014), even inexperienced teachers have shown commitment towards SSIs teaching after undergoing professional development programmes.

Religious beliefs of teachers, as an influencing factor to the teaching of SSIs, has also been acknowledged by different researchers, for e.g., Barrett and Nieswandt (2010) and Lee et al. (2006). One of the teachers in Lee et al. (2006) study was interested in teaching SSIs as she believed SSIs were meddling with what was made by God. Hence, she being a religious person wanted to make sure her students have enough knowledge to understand the repercussions of meddling with

natural order of things. Topcu et al. (2010) also asserted the influence of religious beliefs of teachers on their reasoning, and a possible (negative) influence on their teaching practices. Lee et al. (2012) encountered similar situation in their study where pre-service teachers, expressed dilemmas over the issues of stem cell research due to their religious background. Even when the teachers understood the alternate scientific explanations but found it difficult to accept these explanations and renounce their beliefs.

Teachers' beliefs and other personal factors related to teachers, as discussed above, have a deep impact on the teaching of SSIs. Gaining insights into teachers' beliefs is of utmost importance to close the gap between the enactment of SSIs reform efforts and the intended outcomes of reforms (Ryder, 2015). Capturing these beliefs is not always feasible or easy (Gardner and Jones, 2011, Lee and Witz, 2009, Oulton et al., 2004a, Witz and Lee, 2009) as teachers' beliefs are tacit in nature (Lee et al.,2006), i.e., their beliefs about the teaching of SSIs, nature of science, purpose of science education or their role as a teacher, are deep seeded. The difficulty in capturing teachers' beliefs can act as a roadblock to the path of successful reform efforts. More research is required not just at capturing the teachers' beliefs but also effective methods on making the tacit beliefs and motivations of teachers more explicit.

2.3.2. Internal Context

In order to gain a clearer picture of the factors that impede or facilitate the teaching of SSIs, one needs to consider the context and structure within which the teachers are teaching. As discussed in Section 2.1 numerous teachers espoused the teaching of SSIs, but did not do it because of impeding factors around them, such as, lack of readily available materials, and lack of support from the school leadership. The factors within the confines of a school, such as the lack of teaching resources, time constraints due to vast curriculum, departmental issues, student expectations, that influence the teaching of SSIs are discussed as internal factors in this section.

The lack of instructional time and vast curriculum are the most prevalent hindering factors that were witnessed across multiple studies reviewed (Day and

Bryce, 2011, Lee et al., 2006, Reis and Galvão, 2004a, Ryder, 2015, Ryder and Banner, 2013, Sadler et al., 2006). Teachers reported on lack of time and being under pressure due to vast curriculum that they need to cover in order to prepare students for examinations, due to which they seldom are able to cover SSIs in practice. However, Albe et al. (2014) provides an alternate view on these prevalent hindering factors, where they report that actually it is the teachers' conception about the curriculum that inhibits the implementation of SSI rather than the vast curriculum (or time constraints, thereof) itself. This was concurred by a subject teacher in the study by Reis and Galvão (2009), where the teacher adapted the science curriculum according to the perceived audience in order to effectively address SSIs in the curriculum. While the role of teachers in overcoming such hindering factors cannot be ignored, but efforts are also required at the end of curriculum developers to reduce the already overtly crowded curriculum and/or change the priorities of science learning towards a socio-scientific approach in form of reforms (Tal and Kedmi, 2006).

Lazarowitz and Bloch (2005) showed, in a study conducted with 30 biology teachers, that teachers refrain themselves from teaching societal issues in the classroom as teachers were preoccupied with the matriculation examination (10th class) of students. These examinations were deemed important as they were the external examinations, based paved the path for students' future professional career. Therefore, the teachers were primarily focused on completing the curriculum that is supposed to be evaluated in the examination, which is the reproduction of canonical scientific facts rather than moral or ethical values. This relates to my assertion in the previous paragraph from Albe et al. (2014), whether it's the vast curriculum or external examination pressure that really impelled the teachers to focus on the teaching of scientific concepts, or they as science teachers do not consider moral or ethical issues relevant enough to discuss in their classrooms. Similar hindering factors were also highlighted in Oulton et al. (2004a) study, which included time constraints, examination pressure, lack of teaching material, over-burdened curriculum and lack of guidance. Based on the evidence provided in Oulton et al. (2004a) study, the researchers concluded that the teachers are driven by the traditional settings of teaching science and prefer to "stick to the facts" (p. 497) as this allows them to maintain control of the classrooms while teaching controversial

issues. Day and Bryce (2011) related this facet to the teachers' need to be in absolute control of the content discussed in the classroom as well. For teachers, as noted by Day and Bryce (2011), it is important to know more about the content than the students, so that they are at no point outside their comfort or control level. The control here refers to control in terms of discipline in the classroom, control in terms of the content under discussion, and also the teachers' control on the learning outcomes of students (Day and Bryce, 2011)

Another internal hindering factor is related to the lack of resources for teaching SSIs. This includes the facilities such as laboratories, and lack of appropriate instructional material, that would assist the teachers in teaching SSIs. Lee et al. (2006) assert that preparing the material for teaching SSIs can be time-consuming for teachers and the school authorities or the curriculum developers should facilitate the teachers with such material targeted at the teaching of SSIs in order to save time for them to prepare them.

Bosser et al. (2015) conducted an exploratory study to understand the developments of teachers' classroom practices when teaching SSIs and the challenges faced by the teachers. To this end, teachers were asked about their primary concerns while teaching SSIs, how were they dealing in practice to achieve their aims and the challenges faced by teachers. One of the initial concerns of teachers was to improve students' participation in SSIs teaching activities. The second concern shared by teachers was promoting the personal reasoning and judgement in students. In terms of efforts to achieve these aims, teachers helped and guided the students towards understanding multiple perspectives instead of directing them towards a particular perspective. Furthermore, teachers developed a number of strategies, partly suggested by a mentor (assigned to teachers over the course of the study). These strategies included facilitating students with resources for them to relate to SSIs more personally, provide various perspectives on the issues, involve them by the means of personal written assignments, encouraging a more inclusive approach and showing importance to the perspectives of each and every student. Teachers met certain challenges in the course of implementing and developing their classroom practices. The first challenge was related to the students' expectations. Students faced problem adjusting to the demands of reformed curriculum, and expected the

classroom proceedings to be similar to the old curriculum, where they were just expected to reproduce canonical facts. Students found it difficult to adjust to the new settings, especially *"consider an issue from different perspectives"* (p. 169). The second challenge that teachers faced in this context was due to the tension between teachers' intentions to assign a level of freedom to students for self-learning and teachers' inherent need to control over the students' learningoutcomes.

Another factor witnessed in this study is that the teachers occasionally overlooked the importance of students' prior knowledge on SSIs. Teachers simply assumed that the students have insufficient scientific knowledge to engage in SSIs activities, and resorted to traditional teaching where the students were learning scientific facts. While building a sound scientific base is important for addressing SSIs (Ekborg et al., 2013), it is equally important to explore the prior knowledge of students before commencing learning activities (Zeidler et al., 2011).

Ekborg et al. (2010) conducted a study with 55 teachers in Sweden to investigate teachers' experience of working with socio-scientific issues. As an outcome of influencing factors, some of the teachers felt that lacked support from school leadership. The limited access to resources, controlled by school authorities and lesser communication between the teachers due to school leadership were reported as the inhibiting factors for implementing SSIs-based curriculum. The impact of leadership was also visible in Barrett and Nieswandt (2010) study as one of the teachers who espoused to not including SSIs, did include SSIs in practice when his department leader asked him to. On the other hand, another teacher who espoused to teach SSIs did not actually cover SSIs in practice, as he believed that his department leader might be against that. This also shows the importance of communication and collaboration in subject departments as such incidences can be avoided with better collaboration. Another variation of the impact of leadership was witnessed by Sadler et al. (2006). Specifically, Profile-B and Profile-C (see Table 2.1) teachers felt that they do not address controversial topics in the classroom due to job security concerns. This shows the lack of trust shown to the teachers by the leadership and the amount of interference of school and department leadership in classroom teaching.

2.3.3. External Context

The previous two types of factors provide insights into the personal aspects of a teacher and the internal context of the school. In this section, the factors that are beyond the confines and control of school authorities or teachers and significantly impact the teaching of SSIs are discussed. Note that a wide array of external factors exist that can potentially impact the science teaching, but only those that can have an impact on SSIs teaching are discussed below.

Cultural factors are cited as an impediment by Lee et al. (2006). They suggest that one of the most important considerations in the Korean educational system is preparing the students for higher education in universities to ensure a secure future in social and economic terms. Hence, the primary focus of teachers, parents and school administrations is in tandem with the goals of national level curriculum and the expectations set by these traditions. They focus on ensuring that students achieve good grades in the current evaluation system, which is largely focused on the ability of the students to reproduce canonical facts. This was further concurred by Kim et al. (2013) in their study in Singapore that the examinations are high-stake, especially in the context of Asian countries.

Similar cultural factors were witnessed in Ekborg et al. (2010) study. They reported that teachers were able to teach in a very relaxed fashion, with much more comfort and confidence. This can be attributed to the fact that there are no national exams in Swedish schools. Teachers were not willing to entertain discussions on social, political, economic and other non-scientific issues while teaching scientific controversial issues (Gayford, 2002, Lazarowitz and Bloch, 2005). Teachers were concerned that these kinds of discussions are time-consuming, and might lead to situations pertaining to inherent uneasiness attached to certain issues (Gayford, 2002), which further reflects that teachers lack the pedagogical skills to teach controversial issues confidently. This was supported by similar findings made by Reis and Galvão (2004a) who revealed that teachers considered that discussion of controversial issues is quite relevant but were hindered by the factors like time constraints, over-

burdened curriculum and teachers' inability to identify appropriate topics for discussions. Oulton et al. (2004a) concluded that the primary teachers teaching practices were influenced by the external factors like the prescribed timetable provided by the government through National Curriculum. Teachers also recognised the perspective of the society and law towards a controversial issue also makes them feel compelled to prepare the students to follow the same norm.

The pressure due to external examinations or the national level standardised testing is an important factor that pressurises the teachers to focus on teaching scientific facts (Sadler et al., 2006). The evaluation system primarily evaluates a students' ability to reproduce canonical facts, where on the other hand national curriculum reforms and standards focus on developing a sense of critique in students about scientific concepts by means of SSIs teaching. This dichotomy between the two leads to difficult situations for teachers and students. Kim et al. (2013) highlighted this dichotomy as a tension between high-stakes examinations and implementing inquiry-based teaching in classrooms that puts pressure on teachers. As the exams are high-stakes, the teachers have an additional responsibility of teaching the test-taking skills to students to ensure that they perform well in the examinations. Formal assessment, in general, was found to be a major factor in deciding the extent to which SSIs are covered in classrooms (Levinson et al., 2001). Teachers tend to prioritise their teaching around the topics, which were explicitly identified and formally assessed.

2.3.4. Interaction between the factors

The factors in Table 2.4 are not independent to each other and are rather interacting to produce impact on the teaching of SSIs. Teachers negotiate to these interactions of factors, which result in the eventual influences on the classroom teaching. Bartholomew et al. (2004) presented a case of interaction between personal and external factors, where the teachers that believed in making students' scientifically literate, and were equipped with appropriate subject knowledge and pedagogical skills reported frustrations at the way curriculum set up has made it difficult for them to allocate time activities for reaching their personal teaching goals. Teachers face tensions due to the dual face of curriculum, that on one side

requires students to be able to grasp and reproduce scientific facts, but on the other hand want then to critically analyse all information with a sense of scepticism (Bartholomew et al., 2004). In contrast to these findings, the teacher interviewed and observed by Reis and Galvão (2009) overcame all such hurdles posed by the impediments of curriculum. According to her, it depends upon the teacher to work around the curriculum and include topics, which they deemed important or include activities that could potentially "include controversy" (Reis and Galvão, 2009) (p. 10). This shows the impact of strong personal beliefs of teachers for teaching SSIs, which helps overcome any limiting factors. Similar findings over interaction of factors were reported by (Ryder, 2015, Ryder and Banner, 2013). Although these studies are not specifically in the context of SSIs teaching, but investigate into the interaction of influencing factors (similar to the ones discussed in this section).

The strong belief of teachers can be traced to multiple factors, and one of them is the gradual professional development. In Reis and Galvão (2009) case the teacher's strong beliefs were related to her strong pedagogical skills, which in turn had been formed due to constant involvement in professional development workshops and internships in her career. She at multiple instances attributed her abilities to these workshops, which she believed had a lasting impression on her teaching skills. These workshops were a success as they actively involved teachers in experiencing and discussing the new approaches in the workshop.

Chapter 3 Research Questions

The previous chapter explored some of the key research studies regarding teaching of SSIs, key methods used for teaching SSIs and the factors affecting them. This chapter provides an overview of the research questions and justifications of doing this research in Indian context. Furthermore, in this chapter I elaborate on the meaning in this thesis of the terms 'teaching method' and 'teaching strategies'.

3.1. Research Question 1

RQ 1. (a). What are the methods and strategies that are used by the teachers for teaching SSIs?

- What different methods and strategies are used for teaching SSIs?
- How do teachers prioritise their teaching?

Research Question 1(a) focuses on the different methods and strategies that science teachers may employ in the classroom while teaching socio-scientific issues. An underlying assumption here is that different teachers might use different teaching methods to teach SSIs. The basis of this assumption is that across different research works, reviewed in 1.2, different teaching methods and strategies have been employed by the teachers to teach SSIs (Day and Bryce, 2011, Levinson, 2006a, Levinson, 2008, Zeidler et al., 2011). Hence, it is likely that the investigation of this research question would result in more than one teaching methods. Furthermore, socio-scientific issues are different from the traditional scientific topics, such as the topic of gravitation, in the context of their controversial nature, so it may be a possibility that teachers use different methods or techniques to teach these topics in the classroom. Moreover, given the plurality of views associated with SSIs, using different (more interactive) teaching methods might be required by the teachers. This argument is based on the study by Ekborg et al. (2013) where the interactive methods such as small group discussions and group work are considered as favourable when teaching SSIs. However, in the study by Ekborg et al. (2013) on teachers for teaching SSIs resulted in contrasting variations. These contrasting

variations were seen in the conduct of SSIs lessons, where some teachers wanted full control over the classroom activities and the learning outcomes of students, and consequently followed a more teacher-centric teaching method, while few preferred more interactive methods, such as group work as teachers believed that these methods facilitate students in their learning. Although, just seven teachers were examined in this study still there were differences in the way they taught SSIs in the classroom. Furthermore, the choice of teaching-learning methods has a direct impact on the learning outcomes of students. Hence, the choice of teaching-learning methods is key to realising the objectives of SSIs teaching. Hence, I personally feel that exploring this aspect of SSIs teaching would be quite useful for my study.

Since terms like 'teaching method' and 'teaching strategies' are general concepts and there is a possibility that different readers might have varying perceptions about these concepts. Hence, I will try to provide a scoped definition for these terms.

Teaching methods

The term "teaching methods" has been used interchangeably in the literature and is often confused with teaching strategies, techniques, and even generalized sometimes as a synonym to teaching itself. However, a clear interpretation of term 'teaching methods' in my context is required to approach the analysis of data collected from teachers. Hence, I analysed three definitions of teaching methods encountered in the existing literature, for finding a suitable one for our context. These definitions are as follows:-

Davis (1976) – The term teaching method "refers to a plan, method, or series of activities designed to achieve a particular educational goal "

Hunkins (1980) - "Teaching behaviours are not random behaviours; such methods have form and consistency. They have form in that they have definite steps or stages or sub-behaviours that are recurrent and applicable to various subject matters."

Ebel (1969) – Teaching methods are defined as "patterns of teacher behaviour that are recurrent, applicable to various subject matter, characteristic of more than one teacher and relevant to learning"

Three of these definitions agree upon teaching method being a series of steps or activities carried out by the teacher. These steps, as defined by Ebel (1969) and Hunkins (1980) are depictions of teacher behaviour, recurrent in nature and can be applied to various subject matters. These recurrent steps for instruction are driven by the educational goals of the teachers, and can be decided based on the teachers' teaching strategy. Hence, a teaching method typically comprises of a technique and one or more resources together. For instance, lecture method comprises of lecturing technique, and a resource, i.e., an idea related to subject matter. A teacher could also make use of multiple resources for a particular method; for example, lecture method could include a topic from a textbook, and a PowerPoint presentation. Another example of a method is discussion method that is carried out by discussing (technique) a topic (resource) amongst students.

Teaching strategy

Teaching strategy is an abstract plan that includes an outline of the methods, resources available, teaching goals, to achieve the personal learning outcomes desired by a teacher. The strategies can either be selected purposefully or are devised due to unanticipated changes in the environment of classrooms. The choice of strategies is influenced by a series of personal factors such as the personalized teaching objectives set by teachers, desired learning outcomes, or certain circumstantial factors such as the availability of resources, infrastructure, and time available.

Trigwell et al. (1994) defined the teaching approach as being a combination of the teaching strategy and the associated intention. The associated intentions of teachers are covered in the rationales presented further in this section. The choice of classification of strategies has been adopted from Trigwell et al. (1994), due to its relevance to our context, as it was unanimously inferred during our data collection phase that each strategy is associated with a teachers' rationale for using that particular strategy. The classification of strategy is as follows:

In teacher-focused strategy, the teacher follows a pre-planned strategy, where the focus is on transmitting scientific facts and information to students, without much concern about teaching the relationship between them. There is a little room for adjustment and flexibility in terms of interaction between students

and teacher. The students have almost no responsibility for the teaching-learning process, and the teaching-learning process is just teacher-centred.

In student-focused strategy, the teacher follows a strategy where students are encouraged to accept the responsibility for their own learning, and teacher has more of a passive role and her role is just to facilitate a an environment where students are seen to construct their own knowledge.

In student/teacher interaction strategy, the teacher assumes a middle path between purely teacher-focused or student-focused strategies. The students are supposed to be active in the learning process but are not entirely responsible for it. The responsibility is taken by teacher for it, but fully engages the students in interactive learning. There's a relevant example depicting the usage of student/teacher strategy, where teacher involves the students and students do question back to teachers but teacher maintains the control of the teaching-learning process, where teacher thinks they should be allowed to share their views but thinks they do not have enough scientific knowledge to carry out a discussion on their own.

RQ1. (b). What are the teachers' rationales for these methods and strategies?

- What are the objectives behind the approach they follow for teaching SSIs?
- How do they develop the approach to teach these issues?

Research question 1 (a) explored the teaching methods and strategies teachers' use for teaching SSIs. This sub-part will address their underlying reasons for choosing specific methods for teaching SSIs. It has been already discussed in Chapter 1 and 2 that the guidance provided by science curriculum is usually not explicit (Oulton et al., 2004a). Hence, the teachers interpret the curriculum guidelines and textbook content differently, which explains their inconsistent choices of different methods for teaching. The teachers' choice of teaching method is also related to their varying perception about inclusion of ethics in science and considering science as a value-free subject (Levinson et al., 2001, Sadler et al., 2006). There may be a possibility that the way teachers discuss or teach SSIs in the classroom is different from their own perceptions. There have been contradictory facts about

teaching of SSIs and teachers perceptions in previous research. It was concluded by Gayford (2002) that teachers may have their own personal considerations but they teach in a way so that students may develop their own perceptions about such issues. Contrary to this Lee and Witz (2009) concluded that teachers develop their own approaches based on their own values philosophies, personal concerns and experiences. However, it was also found that teachers tend to follow a neutral aspect of controversial issues (Bryce and Gray, 2004). Keeping in view these differences, this question will focus on how teachers teach SSI in relation to (or not) their own perceptions about SSI in the classroom. It may be one of the possibilities that the teachers might refer to both scientific and non-scientific aspects in their perception towards SSI, but will differ in their approach while addressing these issues in the classroom. This research question is important for my study, as this will also provide me with essential information for RQ2 too.

3.2. Research Question 2

RQ2. What are the factors that influence the teaching of socio-scientific issues in the classroom?

Research Question 2 focuses on the factors that affect the teaching of socio-scientific issues in the classroom. Previous chapter highlighted a range of different factors that affect the teaching of SSIs. These researches have been conducted in different countries but not in India. Since culturally and educationally Indian context is very different, I am hoping to find a range of different methods with different variations than what has been researched in other Western countries. Including this question in my study may help me in examining whether the same factors affect the teaching of SSIs in India or they are different. There might be a possibility that factors affecting teaching of SSI in Indian schools may be similar to the ones concluded in previous researches. However, this should be noted that the curriculum and pedagogical approach followed in India is having similarities as well as dissimilarities with other countries syllabi. Secondly, since SSI have a major characteristic related to the society. Hence, exploring teaching of SSI in Indian context will perhaps reveal different outcomes.

Chapter 4 Methodology

4.1. Introduction

In the previous chapter, I presented the research questions that have been addressed in this study. This chapter describes the methodology adopted in this research study. It presents a description of the research design and the research tools used for gathering data. It further explains the rationale for the selection of particular research tools, sampling of subjects for this study, and brief information on the pilot study. Finally, a discussion on the ethical consideration for this study is presented along with the details about the data processing and analysis in this study.

4.2. Methodology

In chapter2, I reviewed the research literature that investigated the teachers' perspectives on the teaching of SSIs, methods and strategies employed by teachers for teaching SSIs, and the factors that influence the SSIs teaching. A range of research tools was selected by those researchers in order to collect data from the teachers. These research tools include, among others, interviews (Lee et al., 2006, Sadler et al., 2006), surveys (questionnaires) (Anagün and Özden, 2010, Oulton et al., 2004a), and observations (Barrett, 2008, Hand and Levinson, 2012). These research tools were either used alone or in combination with other research tools, for example, Barrett and Nieswandt (2010) used both in-depth interviews and observations of classroom sessions to capture teachers' beliefs about SSIs teaching. Depending upon the context and the purpose of the studies, the selection of these research tools was complemented by a research design. For instance, Zeidler et al. (2011) used a longitudinal research design and captured data from teachers using semi-structured interviews and observations, in order to investigate into the challenges faced by the teachers in implementing SSIs-driven curriculum. The longitudinal research design was chosen, as a long-term observation was required for the introduction of SSIs approach in a classroom and to observe the impact of its enactment. The research

tools were appropriate to the subject of the study as the experiences of SSIs curriculum enactment were to be captured both from teachers' perspective and researchers' perspective. Another example of a research design is that of a case study, which was used by Day and Bryce (2011) with an aim to characterise the conceptual models of discussion used by science teachers for SSIs teaching. The data collection in Day and Bryce (2011) study was done by means of semi-structured interviews. The case study design was chosen by Day and Bryce (2011) as the number of teachers studied was more, i.e., 18 and it required recording and analysing the views of all these teachers. Semi structured interviews have been widely used as a research tool for investigating individual perspectives. Semi-structured interviews provide a flexible means for gaining a deep insight and understanding of the teachers' perception (Gillham, 2000), and hence have been chosen, as a primary research tool in my study for capturing teachers' perspectives on SSIs teaching and to examine the factors that are the most influential in the teaching of SSIs. The interview data, in my study, was triangulated by the data from the observations of teachers' classrooms teaching, as observations allow a first-hand experience of the actual SSIs teaching in classrooms, and they provide a means to substantiate what teachers say in their interviews. The observations sessions were particularly useful to analyse the teaching methods and strategies used by teachers for teaching SSIs. These research tools were employed in an exploratory case study design (Yin, 2009). The primary reason for selecting case study design was that it enabled me to carry out an in-depth analysis of the selected cases and also provided me with a holistic view of teachers' perceptions about SSIs and their teaching of SSIs. The research is exploratory in nature, as no preliminary research exists on this topic in the Indian context. The exploratory investigation in this study attempts to identify the key teaching methods (for teaching SSIs) and the factors that influence the teaching of SSI, which would provide foundation for further empirical studies in this area of research. More detailed explanation of the rationale behind the selection of case study design, and the semi-structured interviews and observations as a research tool have been discussed further in the next section.

4.3. Case Study Research Design

A case study typically concentrates on a single thing with attention to the details. It does not tend to allow one to generalise the outcomes of the study, rather it helps in observing the focus from different angles to give a clear picture of why and how things might have occurred (Thomas, 2011). Simons (2009) considered case study as a design frame that encompasses different methods in its frame. This kind of frame allowed me to use different research tools like observations and interviews for addressing my research questions. Simons defined the case study as "an in-depth investigation from multiple perspectives of the uniqueness of a particular project, policy, institution, programme or system in a 'real life' context" (Simons, 2009) (p. 21). The notion of observing people in everyday situations was also highlighted by Cohen et al. (2013). They observed that a case study assists the readers to understand ideas of "real people in real situations" more explicitly (p. 118). In my research, using a case study approach enabled me to observe the teachers in real classroom conditions, which was necessary for my study.

Researchers have distinguished case studies in different categories. Yin (2009) identified four main case studies; single case-design (the focus is on a single unit), embedded single-case design (the focus is on more than one 'unit of analysis'), multiple case-design (the focus involves study of parallel cases and analysing them in different frameworks in single or multiple cases) and embedded multiple-case design (the focus is on a variety of parallel cases, each with multiple unit of analysis and different frameworks). Here 'unit of analysis' refers to the primary organization that a researcher wishes to study and the propositions of the research build around that particular unit to be studied under different circumstances.

In my research, I followed the embedded multiple-case design framework where schools were the parallel cases, each with multiple teachers (unit of analysis). The teachers were the independent entities and the data from each teacher were analysed in different frameworks as all of them have different perceptions, different teaching methods and different approach towards teaching SSIs. Hence, my research was focused on multiple unit of analysis (teachers), who were studied in different

contexts. Within this frame, I focused on five schools and considered 2 to 4 science teachers in each school for my study.

Yin (2009) further classified the case study designs into exploratory, explanatory, and descriptive case studies. The current study is an exploratory case study. An important pre-condition for an exploratory case study is that no model or theory of the phenomenon under study exists beforehand, or in other words, not much preliminary research on the topic is available. An attempt is made to look for certain patterns by collecting the data first, and subsequently building a model from the witnessed patterns that explains the data. The research questions in an exploratory study attempt to answer the "what" questions. Similar to the characteristics of an exploratory study, in my study due to the lack of any previous such study in Indian context I plan to address the "what" RQs - What are the teaching methods and strategies employed by teachers to teach SSIs, and What are the factors that influence the teaching of SSIs?

The schools selected for this study were from North India, in particular New Delhi, Ludhiana and Khanna. The rationale for selecting these cities for my study were (1) environment-related SSIs are the most widely known SSIs in Indian context and these three cities are particularly relevant in this context being in the top 10 most polluted cities in India. This was concluded during a National Survey conducted by the CPCB (Central Pollution Control Board), SPCB (State Pollution Control Board) and PCC (Pollution Control Committee) of India in 128 cities of 26 states and 4 union territories in 2008 wherein New Delhi, Ludhiana and Khanna were found to be the top 3 worst polluted cities with a RSPM (Respirable suspended particulate matter) double the standard value as per the National Ambient Air Quality Standards for Residential Areas; (2) India is a linguistically diverse country, with a total of 22 official languages and numerous other officially-recognized languages and dialects. The country is subdivided into 29 states and 7 union territories. The physical boundaries of the states have been outlined with an aim to maintain the linguistic homogeneity of the individual states. The official language of the state (or, union territory) was an important consideration in this study. This was important; despite the language of interviews being English, as at times, it was required to be able to communicate with the interviewed teachers and

school administrative staff in their native language. Therefore, it was preferred to select schools in the states (or, union territories) for which I understood the native languages. The three cities mentioned above, i.e., New Delhi (union territory – Delhi), Ludhiana (state - Punjab), and Khanna (state – Punjab) matched both the criteria mentioned above, and were hence selected for this study. Further since mine is an exploratory case study design, the sample of population (number of Indian states / cities) considered was limited to avoid introducing any additional confounding variables. More details about the selection of particular schools and teachers have been discussed in Section 4.6. Within this research design two different research tools were used to collect data from the teachers. They are semi-structured interviews and observations, and have been discussed ahead.

4.3.1. Semi-structured Interviews

Semi-structured interviews were the primary research tool used in my study to collect data for addressing all the research questions. Interviews enabled me to understand an accurate picture of the teachers' perceptions by allowing me to explore their thinking and understanding about SSIs. Moreover, it was possible to guide the interviews, i.e., it allowed the teachers to answer the questions freely and in their own language and, as the interviewer, I could probe for deeper explanations of teachers' responses when necessary. It further allowed a personal-level interaction with the teachers, and I was able to build a rapport with the teachers, which seemed to provide the teachers with a sense of security, as they were able to elaborate their ideas and explain their own perspectives with considerable ease and openness. It was also important to assure them of the fact that the information they provided would remain anonymous at all times and they were not being judged. These advantages made semi-structured interviews a suitable research tool for my study, which would not have been possible with research tools such as questionnaires.

My choice of the semi-structured interview was informed by the flexibility it allows the researchers in modifying the order and/or language of questions to suit specific responses provided by the subjects (Kvale and Brinkmann, 2009). There is no pre-determined list of specific questions rather a list of issues (or suggested

questions) is provided so that all the necessary topics are covered within the interview (Thomas, 2011, p.162). The list of issues not only allows the interviewer to have a control over the topic of discussion but also reminds of the 'potential questions, possible follow-ups and probes' that will steer the conversation towards the direction of the main topic (Thomas, 2011, p.162). Although the interview schedule contained few suggested questions on a number of themes, it still offered openness to change of sequence and form questions in response to a specific answer given by the teacher. Such a move may have encouraged teachers to show more willingness and freedom to express their thoughts and perspectives about SSIs. This not only helped maintain the interest of the teachers in the study but also triggered in-depth responses about their understanding and perceptions. This kind of flexibility is not offered by structured interview where the interviewer asks a predetermined list of questions and is controlled through a standardised interview schedule (Grosvenor and Rose, 2001). On the other hand unstructured interviews are quite flexible and are more like a conversation between the interviewer and the interviewee (Thomas, 2011). However, the unstructured interview has a tendency to lose focus since there is a possibility that new topics may emerge in the interview that may interest interviewee but may not be relevant or significant for the research purpose (Wilkinson and Birmingham, 2003). Since SSIs are as such controversial in nature, there may arise a situation that interviewee deviates or strays away from the main topic and address those issues that are not relevant for the study. Hence semi-structured interview seemed to be appropriate for my study as there were fewer chances that the interview might deviate away from the main topic and it also allowed flexibility for both the interviewer and the interviewee to clarify and elaborate their respective points of discussion (Grosvenor and Rose, 2001).

In context of the individual research questions, teachers were explicitly asked about the teaching methods they use for teaching SSIs and were probed for relevant examples during interviews. For each teaching method explained by the teachers, they were also asked to provide rationales for selecting particular methods. I was also interested to find if the teachers used the same teaching methods differently or not, and hence, they were asked to provide further details when required. For the research question focusing on the factors influencing the teaching of SSIs, the probes were not directed at any particular factor. The idea was

to allow teachers to speak freely about their experiences of teaching SSIs and drawing factors from the data, rather than directing or seeding particular factors, which I considered might impact their teaching. For example, it was evident from early on that school leadership is a strong influencing factor in the context of my study, but I never probed teachers to talk about school leadership or any other factor. The probes were very generic in this context, and the semi-structured interviews helped as it allowed the teachers to speak freely about their experiences.

Despite the advantages offered by semi-structured interviews a few limitations were difficult to overcome. For instance, despite repeated assurances some teachers still had confidentiality concerns in the beginning session. A few teachers even had concerns about the access of their interview data to the school authorities. However, after the initial session I was able to establish a sense rapport with these teachers and assured them that at all times their names would remain anonymous. Further, although semi-structure interviews allow the researchers to be flexible, but at some instances during the interviews, on the spot adaption in the questions or probes are required to maintain the focus of the interview, so that all the suggested themes are covered. I maintained a standardised list of questions, despite the interviews being semi-structured, and I ensure that all the questions are covered. I also maintained a list of all the probes used during interviews to avoid any variation inlater interviews.

4.3.2. Observation

The second research tool that was used in my study to complement the interviews data was observation. The observations provided a sound basis for capturing information, which teachers might have been reluctant to share in the interviews or simply skipped it as they probably considered it trivial and not worth sharing. Observations were also advantageous as they provided an opportunity to directly examine the classroom proceedings (Cohen et al., 2013) and to record actual behaviour than to rely on information based on projected behaviour or preferences (Johnson and Christensen, 2008). Observations also provided an opportunity to substantiate the interview data from teachers as there could be some differences

between what teachers say and what they actually do (Johnson and Christensen, 2008, Robson, 2002).

Observations provided a detailed account of methods and strategies used by the teachers for teaching SSIs, and the classroom interaction of teachers while teaching SSIs. Specifically, observations helped address RQ1 (a) (the teaching methods used for teaching SSIs) as it was easier to examine the teaching methods employed by teachers via observations as compared to interviews. It further gave clarity and further insights into the information elicited from teachers regarding RQ1 (b) (Teachers' rationale for selecting particular teaching methods) and some parts of RQ2 (factors influencing the teaching of SSIs). The observations conducted (See Appendix C) concerned different SSIs, and different teaching methods, and both in class and outside class activities.

It should be noted that the lessons observed during this study were not specifically planned by the teachers for the purpose of this study. The idea was to observe teachers in their natural environment. The lessons observed would have been taught irrespective of the observations for this research. Doing so was a pre-requisite for case study research design, as case studies demand observing the participants in their natural surroundings, and this also mitigated any potential biases that could have resulted in a change in participants' behaviour if the artificial settings were set for observations. This could have further compromised the validity of the findings from the observations. However, the teachers may well have behaved differently with my presence in the room, which is a potential bias for all observations. However, all effort were made to minimise the impact of any such bias, such as taking the seat at the back in the classroom so that teacher is not constantly having an eye contact with the researcher, and data was triangulated using interviews.

During the course of observation sessions field notes were taken and the sessions were audio recorded. Field notes were also maintained for the out of the classroom activities or events, which teachers used for teaching SSIs in different schools. Covering such events that coincided with the time span of this study was of

particular importance to support teachers' claims in their respective interviews. The field notes included pictures of the various artefacts, such as models and posters, prepared by teachers or students as a part of these activities. Not all the schools allowed taking pictures, and in case the pictures were not allowed written notes were taken. For the audio recordings, ideally the teachers should have been given wireless microphones to ensure proper recording of the observation sessions. But this was not done as it was difficult to get permission for this, and it would have been intrusive, and could have led to further possible changes in the participants' behaviour. For the same reason the sessions were not video recorded as well. The audio recording was done by placing two different recorders close to the teachers' desk. This was an effective source of data gathering, except only a few instances where the students in the classroom or the adjoining classrooms made excessive noise, or the classrooms were next to busy streets. The field notes were beneficial in covering the gaps in the recordings. A lesson observation information sheet was formulated for capturing the field notes in a structured manner. This observation information sheet has been provided in Appendix-C.

Although, field notes were beneficial and least intrusive of all, they have their own share of problems. Connor et al. (2009) pointed out that field notes could be an interpretation of the observer about the person or the event under observation, rather than the actual representation of person's views or the event's proceedings. This point was taken into consideration and an explicit attempt was made to remain as neutral as possible and also the field notes were cross-checked with the audio recordings from the observation sessions.

4.4. The Pilot Study

Before conducting the actual study, a pilot study was conducted with three science teachers in Indian schools. The main objectives of conducting the pilot study were as follows:

- Identify potential technical problems or factors that might affect the data collection process;

- Getting first-hand experience of conducting research interviews;
- Trial the questions in the interviews based on the outcome of the piloting stage;
- Practice as a research interviewer, and enhance the data gathering and management skills.

It should be noted that no observations were conducted in the piloting phase, and the only research tool used was the semi-structured interviews. The focus of the pilot included gaining an insight into the teachers' perspectives on the teaching of SSIs, different strategies and methods that they employ for teaching these issues and their rationales for using these methods and strategies and the factors that influence the teaching of SSIs. The three participants for the pilot interview were teachers who were teaching in three different CBSE (Central Board of Secondary Education) board schools in India (the boards of Indian education system are discussed in detail in Section 4.5.2.). Two of the three were female and one male. All of them were teaching science to the students in the 12 - 16 years age group. Following I present a reflection from my interviews and the lessons learnt from these interviews in the pilot study.

4.4.1. Reflection on the Interviewing Process

There were a series of lessons learnt during my pilot study. I present them along with the reflections from the interviews.

Response Bias. One of the key observations from the first teachers' interviews was that I was using the word 'socio-scientific issues' very often in my questions and probes. I believe that this was leading to a response bias, as the teacher was being directed towards the answer I was looking for. The phrasing of my questions and probes were limiting teachers' answer. In individual interviews some lessons were learnt which were corrected in the following interviews, and are presented below.

The environment in which the interview is conducted is very important. An observation from the first interview was that, although the interview was originally planned for 45-60 minutes, it lasted for about 35 minutes only, and with several interruptions. The interview took place in the teachers' staffroom and I found that this caused a lot of disturbance, as there was a lot of movement of teachers coming in the staff room again and again. The teacher also seemed hesitant to answer a few questions in presence of others, and she was also distracted by the presence of other teachers. This confirms the suggestions of Kvale and Brinkmann (2009) that the environment for conducting interviews should be free from any kind of interferences and disruptions as of the interview. As a lesson learnt from this interview, the rest of the two interviews took place in a corner of the school library, which was a relatively secluded place (without much disturbance).

Expectancy Bias. In the beginning of the second interview I was focused on the pre-written questions in the interview schedule, and found it hard to simultaneously read the questions from a paper and concentrate on interviewee's responses. I also realised that I was expecting particular responses from the teacher, and consequently, I was explaining and repeating some questions more often as a way to get the expected response. At some point, I also realised that some questions that were scheduled for the later half of the interview had already been answered and found it difficult to manage the questions in middle of the interviews. Hence, it was a lesson learned that I should not be let my expectations influence the results of my study. Another lesson learnt was that it is better to have a set of generic questions (not in a sequence) in semi-structured interviews, rather than in sequence.

Technical Difficulties. I was also worried about the effectiveness of the digital voice recorder. Unfortunately, I did not realise it before that because of the emptiness in the library, the voice recorded in both the recorders was echoing and was not of such a good quality. At another instance, I realised that the interviewee was speaking in a very low volume, which might have been difficult for the recorder to capture. Hence, I asked her to speak a bit louder so that my recorder could record her voice.

Consideration of the teachers' schedule is important. The second participant was a male science teacher. The first interview with him went as planned and he was very expressive during the interview. My strategy was to begin from a more general point and narrow the scope of the interview as it progressed. This strategy worked for me. However, in the second interview he seemed disturbed and the interview lasted only half the time as planned. The possible reason was that the interviewee was one of the most senior teachers in his department and because of the annual exams happening in parallel to the interview; he had a very busy schedule. The third interview with him lasted only for 14 minutes. I realised that the busy schedule of the teacher could threat the quality and the validity of the data collected. This was a lesson learnt from the piloting that the teachers' schedule needs to be considered before scheduling the interviews, and followed this in the actual study.

The interview with the third candidate was better than the previous interviews, in terms of the research quality. I put the second and third interviews together as suggested by the first interviewee. The teacher was quite responsive in the third interview, as the flow of the conversation was not disrupted. I tried not to interrupt the participant when she was talking and allowed her to speak freely. I was also modifying the sequence of the questions as the interview progressed. In case a response was not clear, I rephrased the teachers' response and asked if my understanding was correct.

The primary objectives of conducting a pilot study were fulfilled and certain other technical factors emerged which were not thought of in advance. For instance, the time or location of the interview needs to be appropriate in order to maintain the quality of the data collected, as these factors have a significant influence on the quality of data collected (Punch, 2009). Hence, conducting a pilot study was an important step in my research.

4.5. The Indian Context

There are certain concepts or artefacts specific to the Indian context, which are prevalent in my thesis. These artefacts/concepts, such as the national

educational boards in India, or the Green Schools in India, have been explained in this section.

4.5.1. Green Schools in India

The "Green School Programme" is an annual inspection or a survey conducted on a national level in schools in India by the Centre for Science and Environment (CSE), India. The Green Schools Program was started in 2005, after the Supreme Court of India made Environment Studies a mandatory subject in the Indian curriculum. There are around 15000 schools enrolled in this program as of now, and every year 25 schools are given awards in various categories based on the survey and inspection results. The survey is conducted to assess the schools, which are working towards preserving the environment and working on sustainable development issues. The topics covered under the Green Schools Program are as follows:

Table 4.1: Topics covered under Green School Program

Water Conservation	Rainwater Harvesting	Green Area	Air Pollution	Energy Conservation	Waste Segregation
Commuting Practices	Biodiversity	Renewable Energy	Waste reuse / recycle	Sanitation	Oxygen Balance
Pesticide Use	Climate Change	Waste Disposal	Water recycling / resuse	Ventilation	Afforestation

More details on Green School Program: ***http://www.cseindia.org/taxonomy/term/20071/menu***

The categories of awards are Green School awards, and Best Manager awards. An activity sheet is maintained for all the schools at a CSE affiliated website called "Gobartimes.org". The "Green School" award is given to the top 20 schools in India for the best environmental activities in India and is further sub divided in two categories – "New Green School" and "Change-Maker" schools. The "New Green School" award is given to the top 10 entries of schools in the Green School Program. The "Change-Maker" award is given to the top 10 schools, which have been part of Green School Program for at least one year. The "Best Manager" award is given to the schools securing the top spot in the categories of Water, Air, Land, Energy, and Waste etc. Many dignitaries in India from various fields like Arts, Politics, Media, and Education etc. are involved in this program and work towards the success of this program.

4.5.2. Educational Boards in India

The education boards can be divided in two categories in India: the national level boards, and the state level boards. The national level boards are Central Board of Secondary Education (CBSE) board and Council for Indian School Certificate Examinations (CISCE) board. The working language in both these boards is English i.e. all the schools affiliated by these boards are English medium schools. The state boards usually function in the primary language of each state. All the subjects, except language subjects, in the schools affiliated to state boards are taught in the local language of the state.

4.5.2.1. Comparison of CBSE and CISCE boards

This section presents an overview of the boards in India, and some detail about the boards, which had been covered during data collection process. There was no deliberate effort made to choose a school based on its affiliation board. As the data collection was conducted in 6^{th}–10^{th} standards of schools (11–15 years age group of students), this section provides details related only to those standards. CBSE board was formed in 1962, and is a registered board in the constitution of India. There are more than 10,000 schools affiliated to CBSE board in India. CISCE board was registered in 1967 in India, and has around 3500 schools affiliated to this board across India.

Assessment System. CBSE conducts two major exams in India which are in the 10^{th} standard (15-16 years old) and 12^{th} standard (17 -18 years old). These are called the Secondary School and the Secondary School Certificate exams respectively. The 10^{th} standard board level exams have been made optional by CBSE recently. CBSE has adopted a new assessment system in past few years, known as Continuous and Comprehensive Evaluation (CCE). The performance of students in 6^{th} to 10^{th} grades is assessed with this system throughout the year.

The CCE system is further divided in two types of assessments:

Formative Assessment (FA): It includes all types of test, formal and informal. The class and subject teachers assess the students during the teaching process or at the completion of units.

Class work

Quizzes

Home work

Worksheets

Oral test

Assignment

Group discussion

Group activity

Experiments

Projects

Summative Assessment (SA): This is a written examination, which assesses the performance of students based on the curriculum of specific terms. The CBSE board sets the questions in this examination. Formative Assessments consisting mainly of projects and assignments make up 40% of the total marks calculated at the end of the year, and Summative Assessments contribute 60% to the final score of students. The schedule of these assessments during an academic year is as follows:

Table 4.2: Newly Introduced Continuous and Comprehensive Evaluation Schedule for CBSE schools

Term	Assessment Code	Time	Weightage
First Term	FA1	April - July	10%
	FA2	July - September	10%
	SA1	End (September)	20%
Second Term	FA3	October - December	10%
	FA4	December - February	10%
	SA2	End (March)	40%

The grading ranges from A1 – E2, with steps of two grades at each level. The curricula for Summative Assessments on which students are assessed are only the topics covered in that particular term. This is a major difference between CBSE and CISCE boards, because CISCE students are assessed for the curriculum of whole academic year at the end of the year.

CISCE conducts three major board level exams in India. The 10th standard exam, known as CISCE (Indian Certificate of Secondary Education), ISC (Indian School Certificate Examination) is conducted for 12th standard students, and CVE (Certificate of Vocational Education Examination) is a vocational training exam taken by students studying a 2 year course on vocational training after their CISCE examination.

In CISCE affiliated schools, the students from 5^{th} – 10^{th} (10-15 year age group) grade are assessed in two terms in an academic year. There are two types of assessments in the schools, namely "Internal Assessments", and "External Examinations". The internal assessments are worth 20% of the total marks, and the rest comes from external examinations. The term external examinations was coined for only 10^{th} standard CISCE exams, but is used for usual pen and paper based terminal exams in the schools. The internal assessments consist of practical work, project work, activity-based learning activities, and case studies. There are pen and paper based exams conducted in September and February, where students are assessed for the curriculum taught until that point in the classrooms.

4.5.2.2. Curriculum and Textbooks

The curriculum and textbooks followed in all the CBSE schools across India are common, and is directed by National Council of Educational Research and Training (NCERT). NCERT books for each subject are used in all the CBSE schools in India. On the other hand, there are no specified textbooks in CISCE schools in India. The board only specifies a list of topics, which need to be covered during an academic year. Because of this, the choice of the books varies from school toschool.

4.5.3. School Leadership Roles

The various school leadership roles in Indian schools are discussed in the Table 4.3, and the hierarchy of these roles is illustrated in Figure 4.1. The role of the director has been forked to show that this role is optional in Indian schools, and not all the schools have a position of a director.

Table 4.3. School Leadership Roles

Role	Description
Management	All the schools covered in this study are private schools, i.e., they are not funded by the Government of India, or any state government. The schools are funded by a board of trustees, also known as school management. The role of school management is to identify the school ethos, formulate a plan for the equitable quality of education in the school, and check the progress of this plan. It further includes overseeing the accountability system of the school, and approving the major expenditure budgets.
Director	The director in the school is an intermediary person between the school management and the school administration (academic affairs). His role includes developing and maintaining healthy relationships between all the stakeholders. It further involves appointing the principal and provides ongoing support and supervision. The director is also responsible for all financial transactions of the school, and approves all the final transactions within a certain threshold. The annual review of the school's progress in meeting its objectives and making necessary changes are part of the role.
Principal	The principal plays a pivotal role in the school administration. This is the highest position in the school leadership hierarchy as far as the academic affairs are concerned. The role involves hiring and removing of the school teachers. The principal is responsible on meeting the academic side goals of the school, and ensuring the school ethos are properly implemented. The school principals generally serve a fixed term position. The admission of students to the schools is also monitored by the

	principal. The major curriculum implementation related decisions are implemented with the consultation of the principal.
Head-Teacher	The head teachers are the consultants to the principal. Typically each school has more than one head teachers, with one head teacher appointed for each section of the school. Most of the schools have three sections, primary (6–10 years old students), middle (11–13 years old students) and secondary (14–17 years old students) sections. Curriculum implementation related decisions are implemented with the consultation of the principal. The head teachers are responsible for organising the section level activities and also ensuring the school ethos are implemented at the section level. The head teachers are responsible for arranging field visits, students' academic programmes, and teacher development programmes.
Subject Head	The subject heads are the responsible persons for the individual subjects in each section. They are supposed to manage the curriculum related matters, and any activities specific to their subject. The recommendations for the teaching methods, the schedule for the tests and other evaluations is for their subjects are decided upon by the subject heads. They report for all progress in their subject, and the feedback of all the teachers to the head teachers. Any issues of parents regarding individual subjects' progress of their children are generally directed to the subject teachers. They also teach their respective subjects, but usually the number of periods taught per week are less than the subject teachers.
Subject Teachers	The subject teachers are supposed to teach the curriculum to the students.

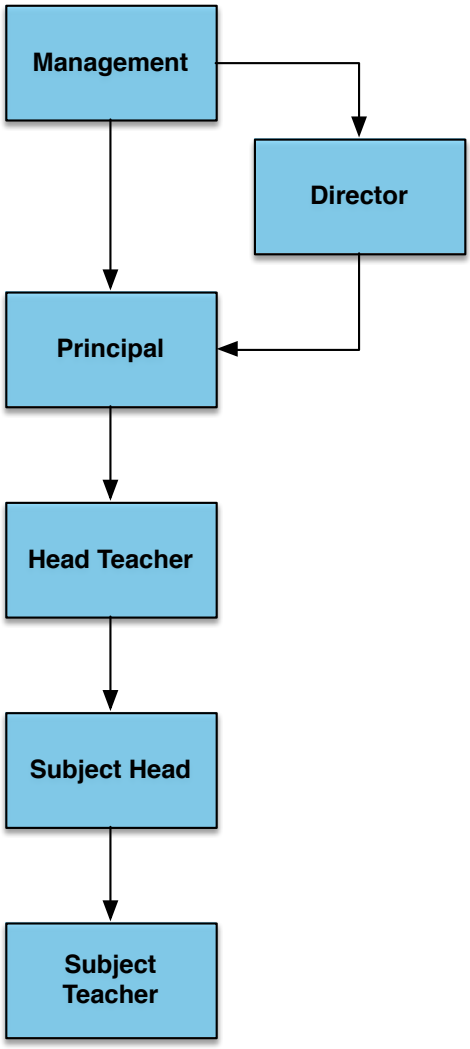


Figure 4.1. School Leadership Roles' Hierarchy.

4.6. Sampling

The criteria and process for the sampling of schools and the selection of teachers as the subjects of my study are described in this section.

4.6.1. Selection Criteria – Schools

The choice of schools to be covered during my study was made based on the following criteria:

- The school needs to be affiliated to a national level board;
- The teaching medium in the school should be English;
- The school authorities shall be willing to participate in my study;
- The school authorities shall be allow me to conduct interviews with middle and/or high school teachers and/or observe their classroom teaching;

The total number of schools to be covered during the study was limited to a maximum of seven, due to resources and time constraints. Around 12 schools matching the first two criteria were contacted for this study, and six schools from these responded positively, i.e., they matched criterion 3. One of the schools was later discarded from the list of schools to be covered, as it did not match criterion 4, and were only willing to assign the school principal for an interview, but the school principal was not a part of the teaching faculty. Hence, in total five schools were covered as a part of my research. The data about the schools and more detailed descriptions about the covered schools have been provided in

Table 4.4, and the vignettes are provided in the following subsection. The schools are referred to by the pseudonyms.

The study further intended to involve the participants teaching the students from the age group 11 - 16, i.e., the middle and secondary section students. The primary school and senior secondary section teachers were not included in the study, as SSIs are not covered much in primary school. The senior secondary section teachers, i.e., for age group 17 - 18 students, were not included in this study as the main focus of senior secondary section students across the nation is on appearing for the professional competitive entrance examinations or the national board examinations, which do not specifically include SSIs. The school authorities demand teachers to focus on ensuring the success of students in these exams, and hence, these teachers do not cover SSIs in their classrooms and also were not available due to their busy schedule. The authorities from the confirming schools were informed about the purpose of the study and were told about the above mentioned criterion of the middle and secondary section teachers teaching SSIs. The school authorities were provided with the relevant information and based on the availability of the teachers a

set of teachers presented with the consent forms and the study information sheet in a brief face-to-face meeting.

The consent and the information forms have been provided in Appendix-D. The teachers that consented to participate in the study were selected.

Table 4.4 provides more detailed information about the selected teachers and their teaching experience. The only exception, from the selected teachers, that were not selected from the above-mentioned process was Victoria. She was selected after the first interviews with Katie and Jane, who recommended Victoria as a potential participant for my study, and later in a brief introduction meeting with Victoria; she consented to participate in this study.

It should be noted that some changes were made to the research plan after the piloting phase. The main change concerned the idea of conducting three interviews per teacher. But this was not the case during the actual study due to the time and availability constraints of the teachers, or only specific amount of time was allowed with the teachers by the school authorities.

As stated earlier, the central focus of these three interviews was to explore teachers' perspectives on their teaching of SSIs. The plan to conduct three interviews per teacher was based on the idea of giving enough time for the interviewer to be familiarised with the teachers (and, vice versa) and to be able to gather enough data to address both the research questions in this study. The first interview attempted to build a level of trust and familiarity between the teachers and the interviewer, and teachers and the context of the study. The first part of this interview focused on getting to know the background of teachers and their professional history. This was needed to understand if there are any possible relations between teachers' current position in the present schools, and their educational and professional background. Although the teachers were familiar with the overall theme of the study (see consent forms in Appendix-D), the term "socio-scientific issues" is not prevalent in the Indian context. In order to give teachers an idea about the subject of the study, certain newspaper articles concerning SSIs in Indian context were presented to the teachers. The link to the news articles shared

with the teachers are provided in Appendix-B. This was done to ensure teachers understand the context of the study, without explicitly nudging their thoughts in a particular direction (to avoid any bias). Alongside the background, teachers were also encouraged to share their experiences of any encounters with SSIs from their personal or professional backgrounds.

The second interview was more focused on their teaching experiences since by this time a level of trust and familiarisation had been built. The primary focus of the second interview was to gather data related to RQ1, i.e., the teaching methods and their rationale for the selection of particular methods. Furthermore, they were asked to share their perception of the teaching of SSIs. If applicable, the teachers were asked to reflect upon their experiences shared in their first interviews in light of their perception of the SSIs teaching.

In the third interview, when the interviewer was familiar with the teaching methods, the rationale for selecting a given method, and the background of teachers, the focus was to understand any factors that the teachers considered had impacted their teaching of SSIs (RQ2).

Textbooks play an important part in the Indian school system. It is expected that teachers who teach in CBSE affiliated schools are likely to follow NCERT textbooks in their teaching practice. Hence, considering the fact that teaching in schools rely heavily on textbook material, a substantial part of the second interview exclusively focuses on the teaching practice and the use of activities prescribed in the classroom. The initial approach was intended towards giving an opportunity for the teachers to talk about their own pedagogical views on their choice of teaching method and the rationales behind it. The main idea behind both second and third interview was to capture the diverse range of ideas and delve more into teachers' experiences. The combination of semi-structured interviews, observations and the printed stimulus material have the potential to provide the teachers with this opportunity and the researcher with a chance to clarify the meanings, to gain insights and ask them for elaboration of their ideas if required.

The above mentioned points for data collection in a given interview were the most dominant themes of the interviews, but any cross cutting discussions

between the interviewer and the teachers were not discouraged and indeed happened. In the cases where three interviews were not possible (for the reasons mentioned in the subsequent paragraphs and in Table 4.4), the general flow of the interviews remained the same. The interview protocols detailing the main points discussed in a given interview have been discussed in Appendix-A.

The schedule for conducting interviews and observations with the teachers was pre-planned according to the timing of the lessons where the SSIs were taught during the academic year. This plan, however, had some unexpected changes as the timing for the consent required from the school authorities and teachers in a few cases took much more time than expected, and created some disruptions to the initial plan. For instance, it was planned to conduct at least one observation of SSIs teaching for each teachers, but no observations were conducted for teachers in two schools - Queens High School and Springdale School. In Queens High School, the permission to conduct observations was not granted by the school principal.

In Springdale School, by the time permissions for a study were granted the examinations in the school were on going. No SSIs lessons, which were relevant for my study, were planned for next 6- 8 months. Instead, to compensate the observations, the teachers allowed extended interview sessions with them, and each teacher in Springdale was interviewed three times in a time span of 45 - 60 minutes, unlike other schools where usual interview sessions lasted 20 - 40 minutes. Teachers were informed beforehand that strict confidentiality would be maintained about their data and at no point in time their names would be revealed, and pseudonyms would be used to refer to their comments in the study. The interviews with the teachers were conducted in the empty classrooms after normal school hours, teacher staff-rooms, or designated meeting rooms. The interviews were recorded with a portable recorder, and a recorder in a smartphone.

Table 4.4. Data Collection Details

School	Teachers			
	Name	**# of Interviews & Observations**	**Experience**	**Key Characteristics of School**
Rockford School	Katie	3 Interviews – 2 Observations	14 years in Rockford School	• **Number of enrolled students = 5700** • **Affiliated to CBSE board** • **Number of years since established = 46** • **Green School** • Active member of Ocean Savers of India. • Seminar & Competitions on themes like International Year of Bio-diversity. • Organized Mathematics of Planet Earth (MPE) competition on environmental theme. • Rainwater harvesting plant in school.
	Victoria	2 Interviews – 2 Observations	12 years in Rockford School	
	Jane	3 Interviews – 3 Observations	16 years in Rockford School	
Blue Bells School	Simi	2 Interviews – 1 Observations	5 years in Blue Bells School	• **Number of enrolled students = 1000** • **Affiliated to CBSE board** • **Number of years since established = 5** • Well known for its Tennis Academy
	Kady	2 Interviews – 1 Observations	1 year in Blue Bells School	
Modern High School	Andy	3 Interviews – 4 Observations	- 3 years in a state board school - 10 years in Modern High School	• **Number of enrolled students = 6000** • **Affiliated to CBSE board** • **Number of years since established = 70** • Focus on Personal development activities for students, spl. Debating & Linguistic skills • Organizes theatrical & street plays, and choreographies on social themes, e.g., corruption, pollution • Organize awareness campaigns e.g. Save Water Campaign • Focus on Sports (some National level players are alumni)
	Daisy	3 Interviews – 3 Observations	- 2 years of teaching age group 11 – 13 years in Modern High School - 1 year of teaching age group 13 – 17 years in Modern High School	
	Annie	2 Interviews – 2 Observations	- 2 years in a state board school - 9 years in Modern High School	
	Nancy	2 Interviews – 2 Observations	- 2 years in a different CBSE school - 14 years in Modern High School	
	Paula	2 Interviews – 2 Observations	- 2 years of teaching in a college - 25 years in Modern High School	
Queens high school	Dolly	1 Interviews – 0 Observations	4 years in Queens High School	• **Number of enrolled students = 800** • **Affiliated to CBSE board** • **Number of years since established = 8** • **Green School** • Extensive Waste Management (Compost pit in school, no use of insecticides & pesticides within school, no use of plastic in premises) • Special support for under privileged kids (slum dwellers and poor families) – A parallel track for these students & are included with mainstream students when ready. • Street plays in villages, slums, and shopping malls etc.
Springdale School	Jasmine	3 Interviews – 0 Observations	- 2 years as a researcher in a research laboratory - 2 years of teaching in different a CBSE school - 2 years of teaching in a different ICSE school - 5 years of teaching in Springdale School	• **Number of enrolled students = 1500** • **Affiliated to ICSE board** • **Number of years since established = 10** • **Green School** • Research based projects are highly encouraged, e.g., Bio-Diesel project • Special lectures & activities for students on moral & ethical values. • Regular workshops for teachers (At least 25 – 30 every year) – with a focus on including latest technologies & innovative teaching methods
	Pam	3 Interviews – 0 Observations	8 years in Springdale School	
	Sofia	3 Interviews – 0 Observations	- Worked 3 years in a state Pollution Control Board - 3 years in a different CBSE school, in a different school. - 7 years in Springdale School	

4.6.2. Vignette of Springdale School

Springdale School was established 10 years ago and is gaining reputation in the field of academics in the city it is situated. The school is affiliated by the CISCE board. For the past five years, the school has been considered as one of the top three CISCE schools in the city based on their academic performance in the 10^{th} class (15 year age group) board exams (National level exams), co-curricular opportunities and growing sports achievements by the students. In a short span of time, the school has proved its niche and is deemed as one of the top along with a few others, which have been working for many decades.

The school management at Springdale like many other private schools in India consists of various industrialists and high-achievers in the field of education, politics, engineering and law. Springdale has a director who acts as a mediator between the management (trustees, board of directors) and academic staff (teachers, head-teacher and principal) of the school. He is responsible for all the academic decisions taken at the school level. The Director was retired army personnel before he started working as an educationalist. In an informal conversation, he shared that he believes that if his country's army can go through most daring and adverse conditions just based on their internal motivation, then when teachers are provided with favourable conditions and motivation; they can surely do wonders and can further infuse the same motivation in students. He has been responsible for arranging many workshops for teachers for improving their pedagogical skills, and from time to time also invites some external agents for example visiting speakers to motivate teachers and educational psychologists that guide the teachers in how to deal with the students of different age groups. In interviews and other informal interactions with the teachers of this school, a fact repeatedly came across that teachers feel that their director and his way of motivating them is one of the factors as to why they and their school is doing so well. Teachers are considered to be important stakeholders in the school, and are appreciated on a regular basis for their work. The director and principal of the school have initiated an appreciation board, and awards in the school where teachers are given excellence awards on a monthly, half-yearly and yearly basis. The awards are adjudged for the contribution of teachers in terms of innovative teaching methods, curricular and co-curricular activities, and for doing exceptionally well in inter & intra school competitions. The

pictures of teachers are posted on this board for a month, or half-yearly, or yearly for respective awards.

One of the teachers interviewed in this school is Jasmine. Jasmine has got a M.Sc. in Biotechnology and a Bachelor's degree in Education. She is from a research background and has worked as a researcher for two years in a research laboratory. Before teaching at Springdale, she taught in 2 different schools from CBSE and CISCE board for 2 years. According to Jasmine towards the end of her employment in her previous school, she was close to give up teaching because she never felt she had the motivation or the freedom to teach the way she wanted. But her husband, who is a professor in a university, encouraged her to take her job at Springdale and motivated her to become a better teacher. She also revealed that her husband guides her and assists her in trying her hand on different research methods that can be used for teaching. Jasmine feels she has rediscovered herself as a teacher at Springdale and feels that teaching is the best thing for her.

The second teacher interviewed in this school is Pam. Pam has got a M.Sc. in Biology and a Bachelor's degree in Education. She has been teaching in Springdale school for the past 8 years and is involved in many other co-curricular activities. Pam appears to be a confident woman and besides being an exceptional achiever in science as a student, she was also a national level folk dancer in her school and college life. In this school, apart from teaching science to 12-15 years old, she is also in-charge of the folk dance club of the school and is actively involved in preparing students for folk dance competitions.

The third teacher interviewed is Sofia. Sofia has got a M.Sc. in Environmental Science and a Bachelor's degree in Education. Her father was an army man and he was posted in a different city every third or fifth year along with the family. She had travelled a lot in India before and after marriage. Before teaching at Springdale, she taught in a different CBSE school and in a different state for 3 years. Presently, she is teaching science to 11-12 years old students. However, this is her first year of teaching student of this age group before that she was teaching students of primary section in the same school from past 7 years.

4.6.3. Vignette of Queens High School

Queens High School was established 8 years ago and is highly reputed in the city due to its unorthodox ways of operating and teaching. It is an English-medium school, affiliated to Central Board of Education (CBSE), New Delhi (India). The strength of the school is around 800 students. The school, unlike other schools in my study, was established with an aim surrounding the idea of creating a healthy environment and making students responsible citizens. The school was chosen in the list of top 10 new change-makers schools in India for winning the Green School award three times consecutively for their contribution towards environment. The fee for studying in this school is very nominal in comparison to other schools; therefore, the students in the school come from most sections of the society.

The management committee of the school comprises of various social activists, educationists, and industrialists and environmentalist, who have a common vision and have previously worked for the cause of healthy environment before the school was founded. The director of the school is an ex-director of the curriculum and textbooks committee for CBSE. The principal of the school, who is also a member of the management committee, is one of the pioneer founders of the school. She has served as a University Professor of Biology, and had been a principal before in another school.

The school's infrastructure has also been designed keeping in mind the ethos of the school. There is a rainwater harvesting system employed in the school. The wastewater from drinking taps and kitchen is also collected in an underground storage, and used for watering plants in the school. Last year the school has been rewarded for the 97% waste reuse. For this purpose, the school premise has a compost pit for waste disposal and treatment of biodegradable waste to manure for use of farmers around school. Similarly, the plastic waste of school is recycled by mixing it with concrete to use for construction purposes. The papers waste is prevented by reuse to the maximum extent possible. All the applications (for e.g., application for absence from school) are written on the back of flyers and pamphlets, and students reuse the same set of books every year.

In an alternative initiative, 75 under privileged students belonging to families living under the poverty line are given free education, food and a ride from-to school. These students are taught separately from the mainstream students until the time they are educated enough to be included among the mainstream students. The school is also involved in awareness programs for the citizens of their city, especially farmers, regarding the importance and ways of protecting environment, and other environment related socio-scientific issues. The teacher interviewed in this school is Dolly. Dolly is M.Sc. in Botany, and Bachelors in Education. She has been working at Queens High School from past 4 years as of date, and teaches Biology to 7th – 12th grade students.

4.6.4. Vignette of Modern High School

Modern High School was established 70 years ago and is the oldest CBSE affiliated school in the town. The school is highly reputed in the town, chiefly due to a long list of high calibre alumni who have graduated from this school. This list includes prominent industrialists, sports persons, actors, etc. It is also reputed due to excellent academic performance of students in 10^{th} and 12^{th} standard board exams conducted by CBSE. Over the years, this school has turned into a brand name and is deemed as a school for children belonging to the elite families of the town. This is also reflected in the fee-structure of the school, which is high by town's standards.

One of the key factors distinguishing this school from others is the focus of this school on developing overall personalities of students, by engaging them in the activities for personal development, such as, sports, debating contests, poem recitations, theatrical plays, and painting competitions. Despite the focus on personal development, there do not seem to be any special efforts in engaging students in any socio-scientific or sustainability related activities. The lack of involvement in such activities might be attributed to the lack of initiative from school authorities and focus on academic and personal development of students. The School management consists of certain dignitaries of the town, such as, industrialists, renowned social workers, doctors, and politicians.

The first teacher interviewed in this school is Andy. Andy has got a M.Sc. in Botany and a Bachelor's degree in Education. He is teaching in Modern High school from past 10 years and has previously taught in a state board school for nearly 3 years. He is a very confident person, with immense amount of confidence in his pedagogical skills despite of using traditional methods of teaching (as claimed by himself). One thing noticed during his interviews and observations is that he's not very happy with the attitude of students (not being moral and responsible enough), administration of the school, and the board regulations.

The second teacher interviewed in this school, Daisy, has a M.Sc. in Zoology and a Bachelors in Education. She has been teaching in Modern High school for the past three years, with initial two years in the middle wing, teaching the students aged 11 – 13 years, and then was later moved to the senior wing of the school, teaching Biology to 13 – 17 years old students.

The third teacher interviewed in this school, Annie, has a M.Sc. in Botany and a Bachelors in Education. She has been teaching in Modern High school for the past nine years, and has also taught 2 years in a state board school in initial years of her teaching career. She currently teaches Biology to students aged 14-15 years old.

The fourth teacher interviewed in this school, Nancy, has a M.Sc. in Zoology and a Bachelors in Education. She has been teaching in Modern High school from past fourteen 'years, and has also taught in a different CBSE board affiliated school for two years before moving to Modern High school. She teaches science to 11-13 years old. Note that, in the middle wing, i.e., wing with students aged up to 13 years are taught science as a single subject. The fifth teacher interviewed in this school, Paula, has M.Sc.in Zoology and a Master's in Education. She has been teaching in Modern High school from past fourteen 'years, and initial two years of her teaching career in in a college. She teaches science to 11-13 years old.

4.6.5. Vignette of Blue Bells School

Blue Bells school was established 5 years ago, and is one of the newest schools affiliated to Central Board of Education (CBSE), New Delhi (India) in the town. The school offers education till 10^{th} standard only, unlike most other schools that provide education till end of schooling in India i.e. 12^{th} standard. The school is fairly new in the field of education, and the main focus of the school is to gain a good reputation in the city. They are primarily focused on getting good grades for students. The school has an esteemed tennis academy on its premises, and is one of the main reasons for students applying for admission to this school. The students who are learning tennis, and want to pursue this sport have a preference towards this school. The teaching system of the whole school is also moulded to some extent to accommodate the fact that most students come there with tennis academy being a priority. There's no specific focus on socio-scientific, or environmental issues in this school.

There are two teachers that were interviewed in this school, with first teacher named Simi, and second named Kady. Both Simi and Kady have studied Botany, Simi having done her Masters and Kady Bachelors in this field. Additionally, both of them have studied Bachelors in Education too. Both of them have no previous experience, prior to teaching in Blue Bells School, and have taught 5 years and 1 year in Blue Bells, respectively.

4.6.6. Vignette of Rockford School

Rockford was established around 46 years ago, and is affiliated to Central Board of Education (CBSE), New Delhi (India). The school was not so popular till 5 years ago, but is rapidly gaining a positive reputation in their town for their improving academic records and the extra-curricular activities in which students can get involved actively. In extra-curricular activities, school authorities mainly encourages their students to participate in promoting environment related socio scientific issues amongst students and awareness in their city in general for a cleaner and healthier environment.

School has been awarded "Green School" award for three years in succession for their efforts and teachings towards preserving the environment from the Centre of Science and Environment (CSE). This, now, has become one of the major focuses of the school authorities to maintain, and somehow, this has a clearly visible impact on the education in this school. All teachers are asked to have environment related topics in mind while teaching, even if they're teaching languages. This school has been in the top 10 Green Schools on a national level in India by CSE in topics like Energy Conservation, Waste Management, and Water Conservation etc. The school administration is involved in spreading the awareness in their city for preserving the environment by the means of circulating fliers, carrying out campaigns on topics like reducing the use of plastic bags, planting rainwater harvesting units in their school premises, cultural activities like street plays etc. School has been actively participating in the cleanliness of water bodies, and recently participated in an International event for coastal clean-up in India, and held seminar on respecting Oceans in their premises. They have inculcated the idea of "Compassionate Citizen" from CBSE in their education programs for educating students to develop compassion for animals. This is prepared in collaboration of PETA (People for Ethical Treatment of Animals). Three teachers were interviewed in this school. The first teacher interviewed in this school, Katie, has a M.Sc. in Zoology, a Master's in Education, and has doctorate degree to her credit too. She has been teaching in Rockford school from past fourteen years. She teaches Biology to 14-17 years old students.

The second teacher interviewed in this school, Victoria, has a M.Sc. in Disaster Management, and MBA in Environmental Education. She actually serves a special position of Environmental Manager in the school. She takes care of the environment related goals of the school, and channels the studies and activities towards that goal. She has been working at Rockford school from past twelve years. She has been appointed by the school authorities to initiate the activities related to saving our environment. She also teaches environment related subjects to all the section for students aged 11-17, twice a month for each section. She believes in making an attitudinal change in students, where they feel responsible towards the environment; rather than something being imposed upon them. She's fairly renowned

for her initiatives towards the 'saving of the environment', throughout the state and has been awarded on multiple occasions to acknowledge her efforts.

The third teacher interviewed in this school, Jane, has a M.Sc. in Botany, a Bachelors in Education. She has been teaching in Rockford school from past sixteen years. She teaches Science to 11-13 years old students.

4.7. Limitations in the Data Collection Phase

There are a certain limitations that were clear from the data collection process. The sample of schools and teachers selected in my study are not representative in statistical terms of all the Indian schools or teachers. The schools were selected from three specific cities of north India. However, clearly defined criteria for the selection of schools provided a possibility to avoid any bias in selection of schools, such as selecting only certain well-known schools, or the ones that have a large number of students. The selection of teachers was completely based on teachers' voluntary choice and hence, reduced any potential bias which could have occurred due to unwillingness of the participants. Further, the different schools had a different outlook towards an external researcher in their premises, and the level of freedom provided to me as a researcher varied in different schools. This included, for instance the limitation of the time allocated with individual teachers in certain cases, or the facilities provided to conduct interviews. For example, at a few instances individual rooms were not allocated for conducting interviews with the teachers. The probes in the interviews were maintained consistently to avoid any inconsistency in the interview data.

The number of teachers interviewed in each school varied, and the number of interviews and observations with each teacher varied. The interview length also varied for different teachers. In an attempt to gain maximum possible information from the teachers in a limited time, the probes during interviews varied for different teachers. Although the probes or the areas to be covered were prepared in advance, the variations were there according to the course of individual interviews. For example, it was important to steer the conversations during the

interviews for the teachers that swerved away from the main topics. These probes, however, were based on my personal judgement and it is possible that teachers could have answered differently with different probes. However, an attempt was made to remain focused on the main topic of the study and formulate the probes accordingly. The lessons learned from the retrospective analysis of all the audio recordings of interviews during the piloting phase helped formulate the probes in a better manner for the actual study phase. Another potential limitation at the level of data collection was that not all teachers' lessons could be observed so as to triangulate the interview data. As mentioned in the sampling of data, this was not possible due to lack of permission from the school authorities in one case, and the mismatch between the time of study and the specific time of teaching SSIs in the classrooms. However, extended interviews were conducted with these teachers to compensate for the lack of observations.

4.8. Data Processing and Analysis

The transcription of all the teacher interviews was done in the English language. Each file was named with the pseudonym of the teacher and the number of the interview with this teacher. For instance, the second interview with Jasmine was named as Jasmine-I2. Each file was then marked consecutively with unique identifiers for my questions or probes and teachers responses. For example, my third probe in Jasmine's second interview has been marked with a unique identifier as Jasmine-I2-I3, and the response for that probe has been marked as Jasmine-I2-R3. These unique identifiers have been used in this thesis when referencing to teachers' quotes during the interviews. The breakup of a unique identifier is as follows:

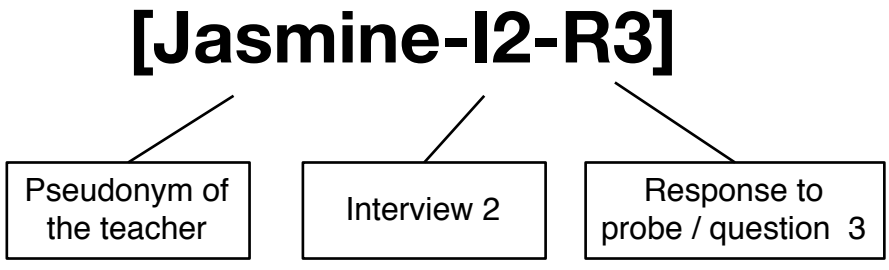


Figure 4.2: Teachers' Quotes Origin Identifier

It must be noted that these unique identifiers were not marked for each and every single line in the interview transcripts, but for the entire response of a teacher for a given question or probe. Some of the comments from the teachers that were in Indian English or (rarely) not in English were translated / transformed into a more understandable format, while carefully maintaining the meaning of the teachers' responses. If the interviews contained any words that could have compromised the confidentiality of the data, these words or phrases were changed so as to maintain the confidentiality.

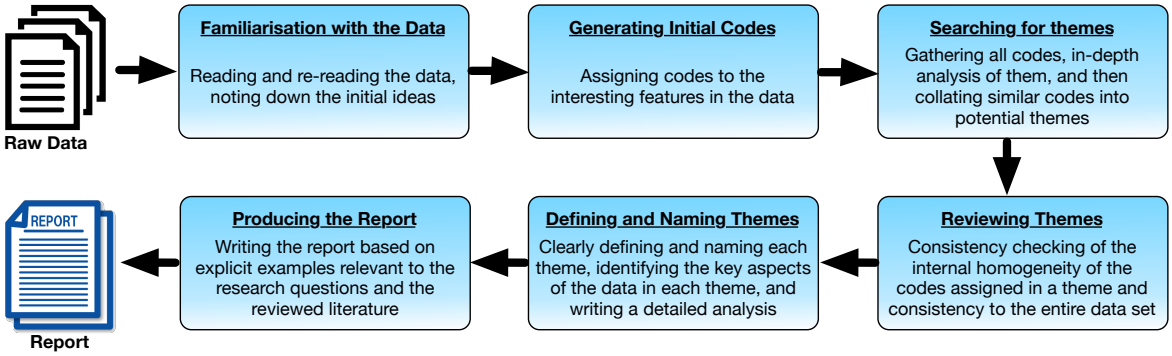


Figure 4.3. Thematic Analysis (adapted from the process described by (Braun and Clarke, 2006).

Thematic analysis was chosen as the most appropriate method for analysing the interviews and observations data in my study. This is a method to identify, describe, analyse and report on the various themes or patterns in the data. Figure 4.2 shows an overview of the thematic analysis process followed in my study, with the guidelines from Braun and Clarke (2006). The input required to perform the thematic analysis is the collection of the raw data to be analysed. The raw data in my study were the interview transcripts, observations, and the field notes. These transcripts were entered into a qualitative analysis software called N-Vivo (Bryman and Bell, 2001). N-Vivo has been designed to assist the researchers for analysing the qualitative data by assigning the codes to text fragments and by querying these codes to retrieve the coded text. This provides a major advantage over manual maintenance of a large amount of text in the form of transcripts and the coding and retrieval of data. The first step in the thematic analysis is to familiarise oneself with

the data. The familiarisation was done by reading and re-reading all the transcripts in an active manner. It means noting down the meanings and patterns that are observed within the data while reading. This was also helpful in developing ideas for the coding (next step) and in a transition from data collection to data analysis phase. Further on, in the next step the initial codes for the analysis of data were developed once I was fully familiar with the data.

Codes are defined as the identifiers of the semantic content or the features in data that are interesting for an analyst, or *"the most basic segment, or element, of the raw data or information that can be assessed in a meaningful way regarding the phenomenon"* (Boyatzis, 1998) (p. 63). For the first step of coding, the codes were all data-driven or from the ideas derived from the review of existing literature. The initial codes marked in the transcripts were done for the whole data, irrespective of their relevance to the research questions. For example, when teachers were talking about their families, or salaries, or other seemingly irrelevant subjects, they were also coded. This was done in order to ensure that no information was missed, and while scoping the codes in the next stage to the research questions, the context in which teachers' responses were made was not lost. Table 4.5 shows an example of the way initial coding was developed for a sample response from an interview. The development of codes was not done for individual lines in the transcripts, but for the entire responses to a question or a probe because the data was contextually rich. Coding individual lines would have disunited the codes from the underlying context, which was not desired.

Table 4.5. Example Coding of Data

Teacher Response	Coding
They learn it, understand the logic, sometimes discuss it, write it and forget it. This kind of teaching does not give them a sense of responsibility or say, like the feeling that `yes' this is our world, we have to do something. I have myself seen that if we teach them this in class they don't give an extra effort. They have so many other subjects to do, curricular and co-curricular activities, why would they be bothered. Here it is the teacher's moral duty to make them realise that this is something crucial and I tell you	• Examination: Focus on testing canonical facts • SSIs reflect moral ethical aspects • Teachers' past experiences • Students' time constraints • Teachers' moral duty • Teachers views on students

students at this age are full with energy, if you show them the right direction, they are like so passionate that they will find the way themselves. You just need to be there and make them realise what is their role.'' [Katie-I1-R13]	• Teachers' perception of her role as a teacher

Once the initial coding was finished for the entire raw data, a long list of codes was available. In the next step (searching for the themes), a thorough analysis of all the codes was performed and the overarching themes were developed from the common codes. At this stage along with developing the themes, the scoping of codes was done in order to focus my analysis on the segments relevant to my research questions. Certain codes from the first step were developed as the main themes, and the others that showcased variations under the hood of these main themes were marked as sub themes. Some of the codes were discarded when there was not enough evidence to support them or the codes were not relevant to the teaching of SSIs. Using these cohesive codes, thematic maps were developed, which proved to be a useful tool for developing themes and analysis. Figure 4.4 shows an excerpt from a thematic map developed during analysis. This thematic map was developed for the codes related to teachers' views on their school leaders, i.e., their respective principals, departmental leaders, etc. It highlights the positive and negative themes around teachers' views on their department leaders.

In the next step (reviewing themes), after collating the similar codes into potential themes, the homogeneity and the cohesiveness of the themes was checked at the level of individual themes and at the level of the entire data set. This means the codes in a delineated theme were carefully reviewed in the context of other codes within a theme (or under sub-themes of the theme in question), and also it was checked if the theme made sense in context of the entire dataset. The validity of themes was analysed based on the constituting codes and any inconsistencies or missing links were sought. The themes were consequently refined or altered depending upon the result of this analysis. An example of this was witnessed when reviewing the initial themes developed in Figure 4.4. On a close examination of the codes in the themes in Figure 4.4, they seemed homogenous internally at the level of individual teachers' responses. However, on grouping these themes and codes by the

responses of teachers from the same school, it was clear that some variation or inconsistency existed. This variation was that in a couple of schools, all the teachers had similar (positive or negative) responses towards their school leadership. However, for the other three schools, a huge spectrum of teachers' responses towards their respective school leadership was witnessed. A few teachers from these schools had talked extremely positively about their school leaders, while the others teachers from the same school seemed to have serious issues with their school leadership. This variation hinted towards a missing link in my analysis. To uncover this missing link, I had to reiterate through the first three steps in the thematic analysis process in Figure 4.3, particularly focused on this.

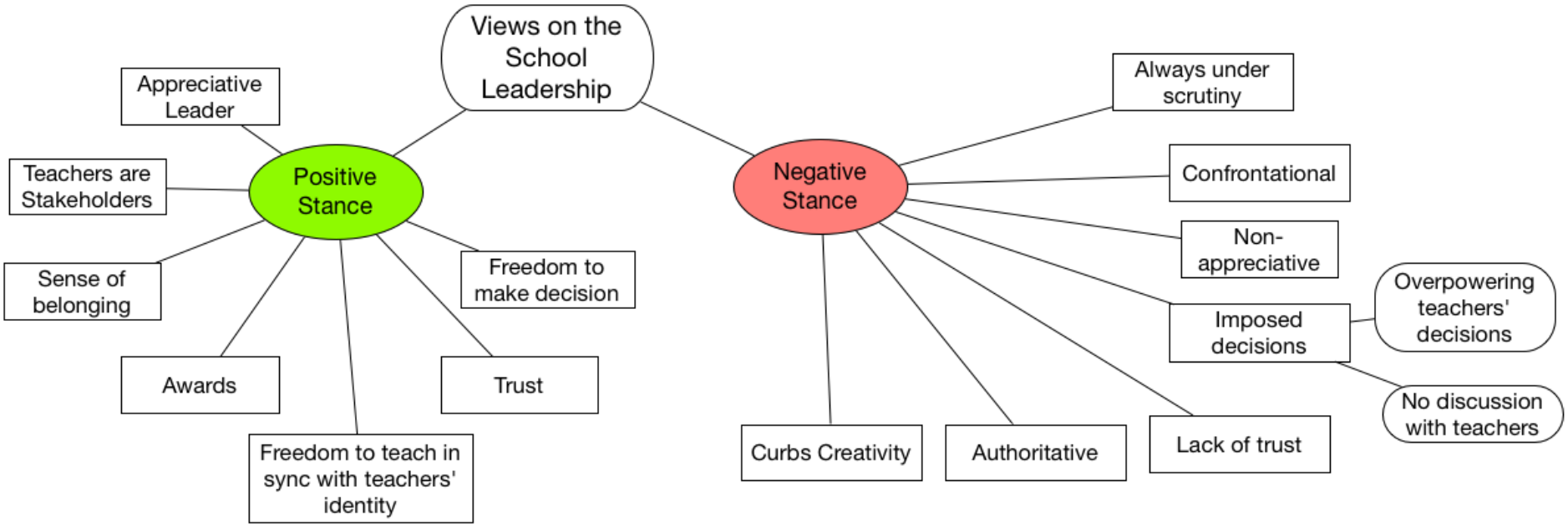


Figure 4.4. Example Thematic Map

As I mentioned previously, my data was contextually rich, hence, at times, I accidentally overlooked certain contextual variables (which had an impact on the delineated themes) or missed such contextual variables as they were not so obvious when considering the responses of teachers individually. However, these variables emerged when the teachers' responses were considered collectively, or the observation data was considered along with the interviews data. Hence, it was important to revisit the data set to account for these missed out contextual variables and refine the themes accordingly. An example of one such missing contextual variable is the leadership style in various schools. When I uncovered this missing contextual variable in a later iteration of analysis, it helped explain the variation in teachers' responses from the same schools towards their school leadership. Hence, it was important for me to validate the themes and check their homogeneity at each stage, both internally and at the level of the entire dataset. The thematic analysis process in Figure 4.2 seems like a linear process, but in practice, it was not a linear process, and instead the entire analysis in my study was the result of several iterations of coding, re-coding, searching and refining of themes.

Once the themes and sub-themes have been captured, the next step was to define the themes. For this purpose, I revisited the collated codes and their related extracts, to identify the characteristics and the aspects each theme or sub-theme covered, and how these relate to my research questions. Additionally, at this stage a clear classification of what was included and what was not to be included in particular themes or sub-themes was done. For example, during the analysis of teaching methods, such as discussions and debates, certain situations narrated by teachers were excluded as there were certain inconsistencies to what teachers termed as discussions or debates and what they actually signify. More details about these have been explained further in the findings chapter on teaching methods. This process was followed throughout my analysis.

Another important consideration during the entire analysis of my data was to focus on developing themes around the teachers' views related to the various aspects of my research questions, and not to judge their views or teaching methods to prioritise or quantify them by any means. My thesis was an exploratory study and the aim was not to report on the best teaching methods for SSIs or to judge teachers'

perspectives or teaching methods for SSIs. For example, while searching and refining a theme on teachers' moral duty or role of the teacher, I found a sub-theme where a teacher referred to the role of the teacher as her duty to show the "right" direction to students or tell them the "right" message, which meant explaining the "right" decision-making process to students so that students are able to make decisions by considering all the related scientific facts and detaching all emotions from the decision. Another sub-theme delineated under this theme (from another segment of her interviews) was that she mentioned the need to not impose their views on students. On a closer consistency checking of the themes, it was clear that these two sub-themes are contradicting to each other. Hereon, my task as a researcher was to report on this inconsistency in her views witnessed in my analysis, and not to judge that her views limited to scientific side of SSIs and were not valid, as they did not include emotional dilemmas, ethics and morals. I did not comment on the rightness or wrongness of her teaching or views. Additionally, there were certain nuances or my personal interpretations during the interviews or observations, which have not been included in the analysis. I have not included such information in analysis to avoid any bias due to my personal opinions. It was one of my ontological decisions to develop themes and present these themes analysed from within the layers of teachers' interviews and classroom proceedings.

Lastly, the themes delineated and defined using thematic analysis formed the basis of the various findings of my study and was described according to their relevance to different parts of the research questions. Using the data under these themes, the detailed written account of these themes was produced. Furthermore, the coding or the themes delineated by this analysis are influenced by my interpretation of data, and might be coded differently by a different researcher.

Chapter 5 Teaching and Learning Methods, Strategies and Rationales Followed by Teachers

5.1. Introduction

In the previous chapter, I explained the process of thematic analysis that was used to analyse the data to address the research questions. This chapter addresses RQ1 in my study, i.e., (a) **What are the strategies and methods that are used by the teachers for teaching SSIs?** (b) **What are the teachers' rationales for these methods and strategies?**

To address this research question, the interview data, the observation data and the field notes were collated, and the themes were identified from the coding in the data encompassing the various aspects of RQ1. These aspects include the investigation (in SSIs context) into the teaching methods, teaching strategies, and teachers' rationales for selecting teaching methods. The process began by transcribing the interviews and then coding the data. For instance, during the coding phase, I constantly encountered phrases, such as "discussions", "discussing", "we discussed", "student discussion" or "group discussion", that were mentioned by the teachers. The various codes were collated under a potential theme of discussion teaching method. Next, the consistency of this theme was reviewed. The various coded excerpts where teachers had talked about discussions or the instances of observation data from teachers' discussion sessions were compared to each other, to analyse their coherence. Certain inconsistencies emerged during the review, as teachers had used the term 'discussion' in a very broad sense covering debates, conversations, dialogues, discussion, etc. This inconsistency in the usage of the term discussion by the teachers, i.e., referring to a multitude of things, was also previously witnessed by Day and Bryce (2011). Subsequently, themes were revised to include only those coded excerpts and their related codes that matched the characteristics of what I term as 'discussion' as a teaching method (these characteristics have been defined further in this chapter). Within the matching codes, further differences were witnessed on a deeper review of the theme. These differences were in the ways the

teachers had used discussion as a method to teach SSIs in the classroom and have been discussed further in this chapter.

Similarly an inclusion criterion was made for all the methods based on literature as well as the observations and interviews data. Through a range of interviews and observations done in the context of this study, four main methods were found that the teachers used to teach SSIs in the classrooms. They are discussion method, debates, lecture method and a range of different activities that the teachers used to teach SSIs. After the identification of the four main methods, interview excerpts were re-analysed and codes were revised so as to take into consideration any details that have been missed before. The listed variations were then sorted according to the key characteristics. These characteristics were then re-structured to form sub-sections of these methods that were identified as different forms of discussions, debates, lecture method and other activities. Excerpts of interviews were then analysed accordingly. Further sections will describe the four main methods and their forms identified in detail.

5.2. Discussions

The term 'discussion' has been widely used in existing literature for science teaching and learning. As already discussed, this term was repeatedly used by teachers interviewed and observed in this study in the forms such as, 'open discussion', 'group discussion', and 'student discussion'. It is to be noted that these terms do not adequately describe the meaning of the term 'discussion'. Apart from the use of different terms by the teachers in the interviews, there has been a range of different activities observed during this study that could be termed as discussions.

Hence, to correctly delineate discussions from other activities in this study, a clear definition concerning the characteristics of discussion is required. Bennett et al. (2010, p. 74) defined key characteristics of discussion activity in their systematic literature review. These criteria were defined to recognise the use of small discussions in science classrooms as different from other methods used by science teachers to

teach SSIs. The criteria presented, for outlining the term 'discussions', derives from Bennett et al.'s (2010) work with added specificities from the scope of this study.

- Key characteristics of discussion, in context of this study are:
- Involves a group of students
- Has a specific stimulus
- Involves a substantive verbal task for students regarding any of the aspects related to socio-scientific issues for at least a few minutes
- Is face-to-face interaction between students, or between students and the teacher

Using these criteria inspired by Bennett et al. (2010), all the interviews and observations data were reviewed, and the activities matching these criteria were demarcated. Following this, a detailed review of all the instances from the data containing discussions was completed, and an initial draft on the use of discussions for teaching SSIs was prepared. However, on a close assessment of this initial draft, different patterns in the way in which teachers conducted discussions were witnessed in the delineated instances of discussion. These patterns varied from each other in certain aspects, such as the role of teachers in discussions, the openness of teachers towards students' perspectives, teachers' confidence in conducting discussions, the flow of discussion itself over time, and the involvement of students during discussions. Based on these variations, these discussion patterns can be broadly classified into four categories. They are the open discussion, funnelled discussion, unplanned discussion and pre-planned discussion. It must be noted that a pattern of discussion is not specific to a particular teacher, and teachers tend to move around the different form of discussions. These categories of discussions and the related aspects are illustrated further on in this section.

5.2.1. Forms of Discussion

This section provides a detailed description of different forms of discussion. This will include an account of the key characteristics of different forms of discussions and the role of students and teachers in the course of a discussion. Most of this analysis is an emergent set of themes from the lessons observed, so examples of the discussions observed are provided to create a vivid picture of how discussion takes place. To illustrate the analyses of teachers' statements, some excerpts from the interviews are provided.

5.2.1.1. Open Discussion

This form of discussion is a teacher-initiated discussion and is carried out before the introduction of a new chapter in the science textbook with an aim to encourage curiosity amongst students for the new topic. The teacher's role in this form of discussion is to create a level of inquisitiveness and to provide intermittent cues during the discussion to ensure coverage of both scientific and societal aspects of the topic. Students might feel a sense of freedom to present their thoughts and views during the discussion as it is intended to be an open discussion where ideas from multiple perspectives can flow freely. The multiple perspectives could be students' viewpoints or previous knowledge from a range of possible angles such as scientific, societal, economic, and moral perspectives.

The discussion begins with an open-ended question or an open situation from the teacher, followed by the responses from the students. Teachers do not constrain the path of the discussion and do not discourage any points of view from the students. However, the teacher does steer the discussion, so it continues to be based on towards the central topic and challenges the students' thinking, using minor cues. This action, in turn, increases the level of participation from students as the discussion progressed. The teacher lets the students discuss the topic until a point where the students would have to resort back to the teacher with their queries. Thereafter, the teacher generally asks the students to wait for her to finish the chapter to see if their queries are answered during the chapter. However, in some instances, teachers also concluded the discussion and then carried on with the introduction of the chapter. In general, it was observed that teachers carrying out

such a discussion in the classroom seem confident about their knowledge and the ability to moderate an open discussion with students.

During one of the observation sessions in Daisy's classroom, such a discussion was witnessed where she began by asking a question to 9th standard (14-year-old) students.

"Did anyone of you cheat in the classroom test yesterday?"

This discussion was initiated by Daisy before introducing a chapter to the students. Students responded by raising their hands, and then she kept on asking the reasons why they cheated and did they feel that cheating was good or not. Within a span of 3-4 minutes, the involvement of the students increased from a few students to more than half of the class. Then the teacher asked,

"What are the other things that we tend to do but should not do?"

Students began to respond giving examples such as corruption, cleanliness, cheating, being disrespectful, etc. Thereafter, Daisy suggested cleanliness, and the focus of the discussion was shifted to cleanliness and pollution very swiftly. Students responded by giving examples from their personal lives, and a student said:

"But are we harming others with it if we are making the lake dirty in our town?"

Daisy responded by another cue "Fishes?" This took the discussion towards pollution and students started talking about their personal experiences, their views about economic and health effects of pollution, global warming, etc. At a certain point all the students were involved and motivated by the discussion, but still had some queries. At that point, Daisy introduced the chapter and asked them to look for the answers to their queries during the chapter. This brought about a sense of inquisitiveness and curiosity amongst the students.

Another example was witnessed during an observation of Nancy's classroom (12-year-old students). Before teaching a similar chapter, she begins with an open-ended question:

"Where do you go for vacations?"

Students responded by mentioning certain hilly areas of India, and were counter questioned by Nancy:

"Why don't you see around things in your own city?"

This led to an avalanche of responses from the students such as:

"What shall we see? A polluted lake? Who wants to roam in this city?"

Then this led to the scope of pollution and students started discussing the pollution-related problems in their city and the way hilly cities are better in this respect. The idea of pollution-related problems in their city involved every student in the class. The teacher further stimulated this by showing a picture of a polluted lake in their city today and 30 years ago. Students were amazed at the picture of the clean lake 30 years ago that they expected has been polluted forever. This stimulated the discussion of problems from their habits, the role of government in pollution control, and the possible cleaning process. Then a student asked: *"Madam, how can we clean this lake in our city, as other states have done that too?",* to which Nancy responded by introducing the chapter and said that they would see the answers to their questions in the chapter and in case they have more questions at the end then she would answer them.

5.2.1.2. Funnelled Discussion

This discussion form has certain similar characteristics to open discussion, in the sense that it is also initiated by the teacher and is used before starting a new chapter in the classroom. However, in this form, before posing a question to the students, the teacher provided a brief introduction to the chapter that limits the scope of discussion to the chapter itself. The teachers adopting such a form of

discussion, as observed, always maintain the direction of the discussion around the topic and very efficiently channel the discussion in case it deviates from the intended topic. However, teachers do not tend to be authoritative while doing so. The aim of this form of discussion is not to maintain a curiosity level amongst students, unlike open discussion but to engage students with the content of the chapter.

This form of discussion usually starts with an introduction to the chapter by the teacher who explains the importance of the chapter in scientific and societal terms. Thereafter, teachers begin the discussion by asking a chapter-related question to the students or by asking the students about their views from the introduction she provided. During the course of the discussion, teachers probe students for their previous knowledge about the topic and if they have read or learnt anything in their previous classes. The discussion ends when students have iterated all the points that teachers were looking for before beginning the chapter. Teachers jot down all the relevant points on the board and then present a detailed introduction to the chapter using the summarised points from the discussion and adding their inputs. Hence, the flow of discussion starts with students discussing the information they have about the topic, and when students are finished discussing the control moves to the teacher. As for the role of students, only those students that feel they have knowledge are involved and not as many students as those involved in the open discussion. This lack of involvement of students could be due to different underlying factors like lack of confidence or lack of knowledge or because students were less curious. However, since I was not investigating the students' perception or knowledge about SSIs, I will not claim any possible factors that I think were responsible for their less involvement.

This form of discussion was witnessed in Annie's classroom (14-year-old students) while teaching the Environment chapter to the students. A common observation made during all the observation sessions of Annie was that she did not appear to be very confident in herself while handling the students in the classroom. She generally avoided situations that she felt could get out of hand. During this particular observation session, she came to the classroom and announced that they would learn about the environment today. She introduced the chapter and also motivated the students towards the topic by repeatedly saying *"You've already read*

things related to this topic in the previous classes, so you have an idea about it". It was evident during the discussion that she didn't want the students to lose the focus from the topic of the chapter, and this was confirmed in the interview after this lesson. For this reason, she frequently directed the discussion towards the environmental ideas in the chapter. Her wish to get her key learning outcomes met or lack of confidence in handling the students can be inferred as a reason for her to choose funnelled discussion that is much more focused around a topic. Initially, students were discussing around the topic as they were gaining hold of the topic in discussion, but at a later stage when students became completely involved and were beginning to cross the chapter's subject boundaries; Annie stopped the discussion and just said *"Let's study the chapter first".*

This form of discussion was also used by a teacher who appeared to be confident in handling the discussions in the classroom. Victoria is responsible for conducting all the environment related activities in Rockford school and initiates environment related discussions in her weekly class. When observing Victoria's lesson, it was found that she wanted the students to understand environment related issues from scientific, geographical, and also ethical-moral perspectives. To motivate the students to appreciate the different aspects of these issues she gave an introduction to various issues before the discussion and also infused a sense of confidence amongst students by letting them recall what they had studied in the previous classes in Science and Geography, related to the topic. Victoria, unlike Annie, was very confident and didn't hamper the flow of discussion even if it steered away from the central topic. She never interrupted a student who was sharing his/her views but afterward she would steer back the topic under discussion by using examples of recent cases from their society as a stimulus. She had knowledge about many environment related issues; awareness programs, latest developments which she used during the discussions. During the observations, she never concluded abruptly and always gave a conclusion that would be likely to motivate students for the upcoming chapters by giving interesting examples from her experiences relevant to each chapter.

5.2.1.3. Unplanned Discussions

This form of discussion is different from the other forms of discussion. The other forms are teacher-initiated or at least the teacher had an idea that the discussion would take place during the lesson. However, in unplanned discussions the discussion is spontaneously triggered by the students' responses during lessons. The flow of such an unplanned form of discussion relies a lot on the pedagogical skills and the confidence of teacher. As it was observed, such form of a discussion has a high probability of going off on a tangent; and it is up to a teacher's abilities to effectively handle the situation and either carry on the discussion in a useful manner or close it down. Both examples were seen during lesson observations.

This form of discussion usually begins when a teacher is explaining something to the class, and a student responds to it with a query or a comment. This might be the trigger and would lead to a discussion with a swiftly growing involvement of students and the exchange of ideas or arguments. There is no certain end to such a discussion, as it could be ended abruptly or could be lead to conclusion depending upon the pedagogical skills or teaching goals of the teacher for that lesson.

Pam described an incident involving such a form of discussion in her classroom when a few thoughts on the clarity of the topic lead to an unplanned discussion. In this particular case, Pam had no intentions to instigate a discussion. However, the circumstances lead to a discussion. Pam was not happy with the outcome of the discussion as students were not able to understand her intended learning outcome which in this case was sensitising the students towards harmful effects of using DDT and pesticides. This highlights that a teacher's assessment of terming a particular discussion as useful or not depends upon whether their intended learning outcome have been achieved or not. This has been discussed further in this chapter.

> *"(. . .) I gave them an assignment on effect of DDT and pesticides on vulture population. 25% of the class gave me some proper positive results. However, rest of them were like, how does it matter to me even if the vulture dies. My point was when you are using DDT product in your garden; it is not going to affect your plant but an organism, which you cannot even think about. I just*

wanted to realise their importance in food chain, and someday they'll get affected too (….) Then this turns more into an open discussion, maybe someone with a sensitive mind or ethics will see my point. (…)" [Pam-I2-R24-25]

As already discussed before, that the teachers have used phrases like 'open discussion', 'group discussion' to describe the activities they conduct in the class. In the above excerpt, although the teacher has used the phrase 'open discussion' to describe the type of discussion she conducted in the class, I have categorised it according to my characterisation of the types of discussion found in this study.

In a variation of this form of discussion, Jasmine described a situation where students initiated an unplanned discussion. Students wanted to have a discussion and asked permission for, that teacher allowed. The teacher seemed to be satisfied with the outcomes of the discussion, as it was led by a group of students.

"Some students come and say they want to have a discussion on it beforehand in the class before they decide a topic (for assignment). (. . .)It was not something started by me; the students had some questions in their mind regarding the applications they want to choose." [Jasmine-I2-R7]

5.2.1.4. Pre-Planned Discussions

This form of discussion is a teacher-initiated discussion, where a teacher plans in advance to conduct discussion and tells students in advance about the day and topic of discussion. This form of discussion, as observed, is usually carried out at the end of a chapter with an aim to foster critical thinking in students.

In this form, a teacher plans the discussion, content of the discussion or the setting in which the discussion would be carried out. The teacher's role in this form of discussion is to plan the discussion and then during the discussion she just acts as a moderator. Students are very active during the discussion and carry out the main part of the discussion and exchange their ideas and the rationales behind them. In most cases, the teacher tells the students beforehand (e.g., at the start of a chapter) about the plan for the discussion. In the end, the teacher summarises all the viewpoints and adds her points to it. This form of discussion usually sees a multitude of views from the students.

This form of discussion was observed in Katie's classrooms. During the first observation session, she introduced a biotechnology chapter involving stem-cell cloning and genetic manipulation. She played a video in the class related to plant cloning, and then briefly introduced the concept of cloning. Then she introduced animal cloning, followed by human cloning in the classroom. She mentioned a term "designer babies" in the context of cloning during the introduction that seems to intensify students' inquisitiveness about the topic. After garnering the interest of students in the topic, she announced that she would conduct a discussion regarding cloning and genetic manipulation at the end of the chapter. She also referred to this during an interview.

> *"In the beginning (….), for this topic (cloning) (...) I always try to keep one lecture free for general discussion. The discussion is (….) related to that what they feel about cloning. What do they think about the process, what do they think about the advantages and disadvantages. And then big questions like the research in this field should continue or not and why do they feel so. (. . . .) In the beginning of the chapter only, I tell them that in the end of the chapter we will be having a discussion or a seminar on this topic. So they keep gathering the information (…..). I devote just one lecture for discussion so that certain opinions get clarified (…)" [Katie-I3-R10]*

During the teaching of the chapter, students gathered information on their own regarding the chapter. As the chapter progressed, Katie provided students with the relevant sources for collecting information about the sub-topics, discussed during the chapter. The growing inquisitiveness amongst students and the need to prepare for the final discussion saw many unplanned discussions during the course of the chapter. These discussions were triggered by the queries students had about the topic, the contradictory views or ethical and/or moral dilemmas they faced while studying the chapter and by the extra information they had been gathering for the final discussion. Katie encouraged all these discussions and encouraged the students' different ideas. According to her, the topic of cloning is relatively new for the students. They do not have much knowledge about it, and if they stay like that, they will not be able to make informed decisions based on scientific knowledge about such issues. She wanted them to be prepared for such situations. Hence, she did not discouraged unplanned discussions, which she saw as a preparation phase for the

final discussion. By the time of the planned discussion arrived; students were well prepared for different aspects of the topic and even the evidence for the ideas they had. They had gained knowledge from the content taught during lessons, unplanned discussions during the course, and the extra information they gathered on their own. Whenever students presented their views during the discussion, Katie probed them for the reasoning behind those views or the evidence they had to back up their views.

Another variation of this form of discussion was witnessed in Daisy's classroom, where the planning was done in terms of the seating arrangement of the students for the discussion and the consensus amongst a group of students. It was observed that Daisy would group the students based on their seating arrangement in the class, and would give them a situation or a topic. Each group was told to decide upon a unanimous perspective amongst them by discussion, for example, the topic was related to biological magnification, and perspectives were pesticides and insecticides should be banned or not. If students had any trouble agreeing with the consensus of the group, she would shuffle the students around to the groups with similar ideas, but didn't allow any disagreement amongst students in a group. She told students to respect each other's opinions, and get the underlying values attached from such discussions.

> *"(…). I always tell them they should take a stand for their opinion but they should be very polite while doing that. Listen to viewpoints of others. "[Daisy-I1-R48]*

Eventually, each group presented their perspectives to the teacher in a round robin fashion i.e. where each student got an opportunity to present his/her views at least once. She concluded the whole process by pointing out the benefits from all the perspectives presented, as indicated by her in her interview too.

> *"See, I just divide the class into groups for discussions and then each one of them puts forward their thoughts and in the end, we try to find a conclusion." [Daisy-I1-R24]*

5.2.2. Rationale behind choosing Discussions as a teaching/learning activity

This subsection includes the rationales of teachers for using discussion as an activity for teaching-learning process in the context of SSIs. This will include the explicit and implicit rationales inferred from the interviews and observation data collected. Each teacher thinks differently, but some of them had similar rationales for conducting a discussion. Hence, we encountered different forms of discussions (discussed previously) driven by the rationales or interrelated teaching and learning goals of a teacher. For instance, a general rationale of teachers to use open form of discussion was to foster curiosity, engage students and to build students' interest in the upcoming chapter.

The funnelled form of discussion had the rationale of garnering interest towards the topic and to contain the discussion within the bounds of the topic. The unplanned discussion didn't have any particular rationale, as the teachers did not initiate them. However, certain teachers did use the opportunity during this form to fulfil their goal of deeper understanding of the issues by students. Hence, they did not abruptly end the discussion and rather steered the discussions to flow in a structured manner. The rationales of the teachers to use planned discussions were to foster critical thinking amongst students, and to develop the conceptual knowledge of students. In addition to these, there are certain other rationales captured during interviews and observations that teachers had for choosing discussion and the specific forms.

5.2.2.1. Discussion as a means to foster critical thinking so as to take an informed decision.

This, as discussed above, is one of the chief rationales for using planned form of discussion. Most of the time, Jasmine initiated the discussions on her own to foster critical thinking in students. Jasmine mentioned that she sometimes deliberately tried to present the situations to the students to learn about their views,

and additionally to test her capability to perform in a particular set of controversial situation.

> *"I always start by asking them questions which lead to discussions (….) or I sometimes ask them [students] to write a write up or prepare a project and record the things that are available on the internet and then compare and discuss it. Some topics are like that, that you can't teach them; it's better to involve whole class in it to have a wider perspective. And students do respond also." [Jasmine-I1-R19]*

It can also be interpreted from her interviews that she wants students to be able to articulate their perceptions scientifically without any dubious justifications. Whenever she encounters multifarious quandaries regarding students' ethical, social, moral or religious values, she attentively listens to them and tries to understand the situation scientifically.

> *"It is only during discussions that we get to know that a particular child is feeling irritated with a type of perception and they give their opinion if they think that teacher is listening to them. So the next day, they come with so many queries and they will keep on asking questions unless they are not satisfied. If they don't like your opinion, then they say it on your face. "Fine mam, your opinion has logic but I don't agree with it." So you know that this happens."[Katie-I3-R14]*

5.2.2.2. Discussions as a means to make students aware of an issue

Teachers sometimes also started discussions with a particular topic because they wanted to sensitise students towards the ethical-moral, or societal aspects of a SSI. An example was witnessed in Pam's interview where she gave an assignment on 'whether DDT and pesticides should be used or not?' to her class with a learning outcome, which apparently wasn't fulfilled. She wanted to make students aware of the SSI, but according to her, students didn't understand the gravity of the situation, and missed out on the message, which she wanted that should have been

conveyed to them. Therefore, she chose to resort to another method, i.e., discussion, implicitly for the fulfilment of that objective. This suggests that teachers may have an implicit message in mind, which they expect students to understand while choosing a method, or activity for teaching about the issue. In case students have different understanding of the situation and do not get the expected message, some teachers may feel the need to go the extra mile to make them understand what they thought was the actual message from the discussion.

It can be interpreted through Pam's interview excerpt (See section 5.2.4) that when teachers use the terms like 'aware' and 'realise', teachers want the students to recognise the social and ethical aspects of SSIs. They want to trigger the thought processes through which students are able to reflect on the multifarious nature of SSIs. By discussing these issues in the class, the teachers tend to expose the connection of SSIs and their real lives.

Katie's statement also reiterates the same concept of discussion of SSIs in the class as a means to make the actuality of SSIs clear to students i.e. to make students aware of the gravity of the existing scenarios.

> *"See we do it with a perception that if we are able to change even 1% and not exactly even change like aware them, making them explore their mind and get that thought process into action." [Katie-I1-R24]*

5.2.2.3. Discussion as a means to explore student's ideas and opinions about SSIs

Further insights into teachers' rationales for teaching SSIs revealed that they consider discussion as a window to peer into students' understanding about SSIs. For instance, as noted in Katie's interviews and observations (See section 5.2.4), certain insights into her personal preference for choosing discussions as one of the methods to teach SSIs are that she wants to have a deeper understanding of students' views about a specific SSI. She believes that given an opportunity, students can articulate their opinions about SSIs through discussions. She also added later in

the interview that since the internet has become an accessible source of information, it has become quite important to listen to the views students hold.

> *"Now days students are not like that whatever you teach them and they willagree to it. They get up and voice their opinion whenever they don't like it. So it is not that students are not aware, internet is there, they go on the net and see everything and much more than what is required by the syllabus. " [Katie-I3-R14]*

In an informal conversation after the discussion session in the class, she claimed that sometimes students' tend to share a personal connection with a SSI especially when they are talking about their daily lives experiences. Hence to address the quandaries they have related to a specific SSI can be dealt within the boundaries of the class through discussion. Considering the fact that students listen to each other views through the course of discussion also brings about clarity in their own ideas. In pursuit of her aim, she follows a very student-focused strategy. Besides giving an opportunity to students to articulate their views, she also creates an open setting where students can also refute teacher's perception by justifying their opinion based on evidence.

Jasmine also believes in the same thought and for this, she strives to create an environment for the students where they can work with each other and share the information. For this, she believes in arranging the students in different groups and expects them to gather the information about the allotted SSI from different sources so that it can be discussed late in the class.

> *"I ask students to discuss things, (. . .) I allot them the topic, and I ask them to get the information. They get the information from the Internet, newspapers, You tube, Discovery channel, (. . .) and in this way they get more in-depth knowledge. (....) This is what you want from the students, so they get more involved with the topics not just in terms of text book learning but overall also." [Jasmine-I1-R15]*

This quotation seems to indicate that Jasmine chose discussions to delve more into the ideas students gained by interpreting the myriad of information accessible to students through different sources.

"See, if there's no interaction in the class then it's not effective then you're just imposing your views on the students. It's very important to bring things out of them, what do they think." [Daisy-I1-R38]

5.2.2.4. Discussions as fillers to rejuvenate the students

The other rationales witnessed is that to use discussions as fillers by the students to lighten the mood of the classroom, or to rejuvenate the class when a teacher feels students are tired or when they have spare time between two chapters. Teachers generally did this by choosing topics that would interest the students and they also had some previous knowledge about such topics.

Jane used the planned form of discussion as filler between two textbook chapters. After completion of a chapter Jane conducted a discussion for a few minutes. This discussion was usually on the contemporary issues that students witnessed in the media. Sometimes, she made use of specific resources such as certain TV programs and discussed them in the classroom. In this particular example she was talking in reference to a chapter (Pollution of air and water), which she had just completed. It was observed that this discussion was usually focused on the latest developments and research findings. Teachers and students were transmitting the knowledge they have gained from different resources.

"Generally, when I am finished with the chapter then I ask them to take out a period where they do something, and discuss something to rejuvenate. This is just to lighten the mood. That period goes in discussing what latest things we've seen on TV (…). Sometimes it's after one-week, or even two weeks (….) and they also come to me with their queries (….). Then they [students] ask questions they've seen on TV or internet." [Jane-I2-R2] "I've myself told them to see some specific programs on Discovery channel. I myself watch them too, and if I find something interesting I tell them in the classroom." [Jane-I2-R10]

One of the other examples encountered with a similar rationale was during interviews where Jasmine said she uses discussions as fillers when she feels that students are tired, or she has no more content to cover in the classrooms. At such a time, she prefers using discussion to rejuvenate the classroom atmosphere and to retain the interest of the students in the topic. For instance, Jasmine reported that she prefers using discussion as fillers, when she thinks that the students are losing interest in the topic and are not actively involved in the classroom.

> *"(. . .) I take all this (discussions) as fillers. Whenever students are quite saturated then the topics related to both science and society are quite good to discuss and break the monotony. (. . .)" [Jasmine-I3-R11]*

5.3. Debates

One of the four teaching methods, which came across during data collection, for teaching SSIs was debates. Not all the teachers interviewed and observed in this study use debates for teaching SSIs. The ones that said that they use debates and some that don't even actually use debates have often used the term debates interchangeably with discussions. This possible confusion or an interchangeable use of terminology is probably because both these teaching methods involve verbal interactions amongst students involving the teacher. Hence, it is important to clearly distinguish certain key characteristics of debates, so as to clearly delineate methods that are actually debates or discussions, irrespective of the terminology used for them by the teachers. The key characteristics of discussions have been previously discussed in 'Discussion' sub-section.

In context of this study, debates are the verbal interactions in a classroom where students, in a formal set up, discuss a particular topic from two or more contrasting perspectives. The debates are more formal and structured in comparison with discussions. The class is divided in two or more groups for argumentation during debates, and it is relatively more important to justify the arguments, with evidences or explanations, made by any group. The justification of arguments is important when a group's claims or arguments are counter-questioned by the opposite group(s) or by the teacher. However, at the core of debates for SSIs

lies argumentation between groups over different perspectives that a teacher tries to address in the form of a message or an ending note, towards the end of a debate.

As discussed previously, a common feature between these forms of debates is that the teachers did allow a certain level of argumentation between the students. However, the cases where the teachers term their method as debate but tried to avoid any argumentation, or any counter questioning between groups, despite the students presenting contrasting perspectives, have not been included in debates.

Once such instance is from the Sofia's classroom where she moulded a debate topic in a way to avoid argumentation between students, and still getting the intended message, i.e., her teaching goal fulfilled from it. The topic was "Should pesticides be banned or not?" However, she asked the students to give their views on "Do's and Don'ts for avoiding pollution". She believed that use of pesticide will come up in the range of this topic. Students began by reporting the two different views. When they mentioned that pesticides cause water pollution and shouldn't be used the teacher asked the students "Why shouldn't we use pesticides?" With this Sofia turned it into a cause-effect discussion to sensitise students towards the intended message of the lesson, where the cause is the use of pesticides and the effect is water pollution or the increasing mortality rate of fishes, etc. Despite, students discussing varying views, this form of discussions is not considered as debates.

> *"It is more like a discussion cum debate. I gave them a topic and then I divide the class into two parts, one that deals with what you need to do and other what you need not to do. Basically DO and DON'T. Sometimes we have PROS and CONS, but it depends on the topic also if I am talking about 'save water', I will prefer to teach by dividing the class into what to DO and NOT TO DO. But if I am talking about pollution, then I won't choose this method. I don't want them to argue with each other. Then I work on cause and effect. So I divide them in groups which work on what causes pollution and what is the effect of pollution." [Sofia-I3-R18]*

When probed further, she added that she tries to prepare students to work on two distinct angles of a topic but avoids any situation that might turn out to be controversial. She reveals that she won't prefer topics like pollution to be 'sort of debated' in the class as this may lead to a situation where one student suggest something and the other is having a complete opposite view which may further lead to arguments. Though she claims this method to be a 'discussion cum debate', this kind of method will not be considered as a debate. To reinforce what has been said before, this section is based on the proposed key characteristics of debate that I have described earlier and not what the teacher claim as 'debate'.

5.3.1. Different forms of Debate

On an initial analysis of the data concerning debates, two themes emerged in the form of two different forms of debates conducted in the observed classrooms. These forms are primarily distinguishable on the account of a number of perspectives discussed during the debate. Some of the debates had only two contrasting perspectives where students were proposing or opposing a topic. The second form saw multiple perspectives being discussed during the debate. Both forms of debates will be described further in this section.

To further validate the emerging themes against existing pieces of research papers were considered. These existing research pieces were not just limited to debates in the context of SSIs, but to debates in general for teaching and learning. Jerome and Algarra's (2005) work came out to be on similar lines as emerged themes. They define two forms of debate: adversarial debate (two perspective debate) and deliberative debate (multiple perspective debate). In adversarial debate, students are asked to speak for or against a motion or proposal, which is similar to the first form of debates delineated from data for this study. The deliberative debate is defined as being a more open form of debate where a range of opinions are explored during debates, and is on similar lines to the second form analysed in this study's data. This matching, to some degree, validates the outcomes of forms of debates from this study's data and these forms are henceforth named as "Two Perspective Debate" and "Multiple Perspective debate". The teachers have used these forms of debates to teach SSIs to students of age group 13 and more. This

observation is consistent across all the teachers that used debates as a teaching method.

5.3.1.1. Adversarial Debate (involving two groups)

First is where the debate is carried out between two groups of students supporting two contrasting perspectives i.e., a proposition group (For - topic), and an opposition group of students (Against - topic). However, within this form notable variations were observed in the way the teachers conducted debates in the classrooms. The sub-sections below will further describe the variations observed in detail.

Teacher limiting the scope of debate. This particular form of debate was observed in Daisy's classroom. Daisy was teaching 14-year old students a chapter on 'Natural Resources' which included topics on air pollution, water pollution, biogeochemical cycles, greenhouse effect, how these are inter-related and how human activities causes changes in the atmosphere further leading to global warming and ozone layer depletion. In one of the lessons observed, Daisy was carrying out a discussion where she was narrating a few real-life examples from her experiences. She also asked students to narrate their real life experiences and opinions on how human activity causes pollution. One of the students disclosed that the area in which he resides is polluted. He claimed that the high level of pollution is due to the dye producing factories nearby the residential area. Before Daisy could add anything, another student stood up without raising his hand and said that he credits the high level of pollution to the excessive smoke emitted by automobiles. This triggered an argument between both the students, where the first student added that government has banned diesel autos and have replaced the same with Compressed Natural Gas autos. He further added that if police can fine and ban automobiles for excessive pollution, then factories should also be banned.

To calm down this situation, Daisy intervened and said,

"What's the problem you're both saying the same point? You both are in favour of bans, then why are you arguing?"

Then the first student replied,

"Madam I am in favour of banning factories but not cars and other automobiles".

In the midst of this conversation, few students added that they think that factories, as well as automobiles that produce excess pollution, should be banned. It was evident that three perspectives emanated from that situation. However, to contain the multiple perspectives being debated in the classroom, she chose to merge the three perspectives into two contrasting perspectives "Ban everything", and "No banning". She told the first and second student that since they were actually refuting the ban of automobiles or factories, they should form one team and speak 'Against the ban' and the other group should speak 'In favour of a ban'. However, this led to contrasting views within first group and led to more conflicting arguments. The volume of the argumentation began to rise in the classroom after Daisy's decision to contain the perspectives to only two. This particular case indicates that there lies a significant degree of autonomy in teacher's hand. By making use of this autonomy, Daisy was able to change the course of debate by merging three variant perspectives into two perspectives that she believed were right for this particular topic.

Students defending their own viewpoint. Jane is one of the two teachers that used debates as a teaching method for teaching SSIs for younger students (aged 11-13 years old). She followed a specific technique while conducting debates with younger students. It was observed in one of her classes that Jane wanted to conduct a debate on the same topic as that reported for Sofia previously, "Should pesticides be banned or not?". However, her way was different. She wrote on the board "Insecticides and pesticides are good for crops but cause air and water pollution". Then she asked the students to present their views about the statement. She asked students to talk about both the perspectives.

Initially, it seems that a discussion was going on in the class. But, once the students gained the momentum in putting forth their opinions openly, Jane introduced the main topic of debate "Should we ban pesticides or not?" Thereafter students began presenting their arguments in the form of a debate where one team

was talking about banning the pesticides and other refuting the ban. Jane allowed the students to shuffle their position and sit with the students who were of the same opinion. Jane preferred preparing a platform for these younger students before beginning the actual debates, as similar to Sofia; she also thought it's difficult for younger students to form arguments. However, instead of not using debates at all she used this specific technique where students first reach a stage where they can form certain substantial arguments. When questioned in a post-observation session, Jane reaffirmed that she did try directly starting a debate with younger students but it did not work as they were unable to directly come up with substantial evidence to back their ideas or arguments. Hence, she chooses this method where students can first discuss and form ideas in a better manner before starting a debate.

Student defending the assigned viewpoint. As well as students being allowed to defend their own viewpoint in class debates there were also situations where students did not choose proposition or opposition sides of free will. The students were partitioned into groups based on their seating arrangement, gender, etc. This means that the students may need to justify a position that they do not support which in itself is distinctive and challenging activity. This kind of debate was found to be conducted on a topic that students are already familiar with and hence takes place at the end of a chapter. The two perspectives regarding the topic are manifested by the nature of topic itself, e.g., a topic "Should pesticides be banned or not?" The role of the teacher in this particular form was seen with a possibility that it may change over the course of time. Though this change in the role of the teacher cannot be strictly associated with this form of debate, and can be different in the same form of debate. At the start of the debate, the teacher's intended role can be perceived as to assign groups and to channel the debate towards the intended message or teaching objective.

This form of debate was witnessed in Annie's classroom, where she came to the class with an intention to conduct a textbook activity on "Should pesticides be banned or not?" The students were already familiar with the topic. She said,

> *"Tell me what you think about it. Raise your hands before speaking, and wait for others to finish if you have any comment or question for what they are saying".*

Very sooner she noticed a sense of disagreement amongst the students sitting together and there was a feeling of situation getting out of hand. So she asked the particular set of students sitting in that row,

"How many of you propose banning of pesticide?"

Based on the majority of raised hands in a section of class she segregated the class into proposition and opposition groups according to the seating arrangement. This also led to a change to the teacher's role as earlier she was just a facilitator for an activity and asking students to present their views on the turn; whereas now she had to remind students constantly that they have to talk about opposing the ban as they're sitting in the opposition group. This led to many disruptions in the flow of the debate, as some vocal students didn't agree with the perspective assigned to their group. The decorum of classroom soon was disrupted, and the students became argumentative within the group. The process of the debate witnessed a string of claims without any adequate justifications from the students. There was a lack of harmony within the two groups. This could be attributed to the observed occurrence of disagreement within the group for the position assigned to them by the teacher. This led to an abrupt ending to the debate and the teacher moved onto her teaching of a new topic.

This particular situation gives an opinion that apart from the disagreements taking place in between the group, the sudden disruption of this particular activity may be attributed to a range of different reasons. This may include the teacher's pedagogical skill, teacher's intended goal and class size (in this case 47 students) and more importantly, the challenging job assigned to the students to talk about the opinion they don't agree with. However, a clear evidence to claim this was notavailable.

A similar form of debate was seen in Jasmine's class, where Jasmine mentioned that she prefers debating topics that the students already have knowledge about; as for newer topics the students cannot bring in their personalised views in the debates and just tend to copy facts and figures from the Internet. None of her classroom sessions were observed but she did mention in her interviews and

other informal conversations that she divides the classrooms in teams of girls and boys, or divides the classes based on seating arrangement. A contrast to Annie's experiences is that Jasmine expressed that she did not face any difficulty while conducting this form of debate, although she didn't partition students into groups based on their choice either. One notable difference is the difference in class size (in this case 20 students).

> *"(. . .) It's not that we want them to have an opinion copied from Wikipedia or any other internet source, we want them to respond. Like when we are having a debate (….) on ban of pesticide then usually the discussion is very good. Students are energetic; they give so many points, some from [the] internet, some of their own."[Jasmine-I2-R18]*

5.3.1.2. Debates with multiple perspectives

In the second form, the debate is carried out between different students (in groups or individually), which support multiple perspectives. In this form of debate, the teacher usually tries to address these perspectives towards the end of the debate. Victoria used this form of debates in her classrooms, and was observed in her weekly session in a section of 10th standard (age group 15) of Rockford school. Victoria conducted a debate on "Is growing industrialisation affecting a local lake?" Before starting the debate, she summarised what the students have done in the assignments regarding the concerned topic in the summer vacations. Students already had some idea about the topic and were prepared with the information they had gathered from the Internet or local newspapers and in their assignments. For the initial 5 minutes, there was a discussion going on in the class. After listening to students for 5 minutes, the teacher wrote the different perspectives, which came from the students, on the board. Then she used different pictures to trigger the untouched ideas. She displayed a picture to the students of a lake 25 years ago and now to increase the participation level of students. The level of engagement of students in this form of debate was more that observed in other forms of debates session. The teacher was seen taking a back seat during the debate and allowed the students to talk about any perspective concerning the topic.

A strikingly different aspect of this debate was that the debate was not about two contrasting answers; it was about the multiple perspectives. Perspectives related to the economic growth, long-term effects of growing pollution in lake to agriculture in the area and the breadth of the problem in a wider horizon, the measures taken by developed countries to counter similar problems, the expectation of developed countries from developing countries, etc. Along with moderating the debate Victoria also inputted her own ideas and facts related to the various perspectives discussed during the debate.

In another example, as seen in observations Victoria used certain stimuli for the debates. As quoted by Katie, working in the same school, Victoria tells her students to watch certain videos or TV programs which act as a stimulus for conductingdebates.

> *"We also see that there are many channels on the television which make such kind of programmes. We [Actually Victoria] asked some of our students of 10th and 11th class to see a video; it was a Discovery Channel video 'Global Warming-What you need to k n o w ' . After students watched it, they had so many strong opinions. They actually said 'but mam may be its good, because than there will be more carbon dioxide and then there will be more chances of survival of plants'. So you know, you don't know what is cropping in their minds, but our efforts continue. To be very true, I had no idea about this video, but our environmental manager (Victoria) asked them to see it. You should talk to her; she is quite good in all this." [Katie-I1-R27-28]*

This excerpt of Katie's interview particularly reveals that Victoria was considered as a skilful teacher to teach SSIs by her fellow teachers. This also suggests that Victoria's fellow teachers exhibit confidence in her teaching techniques more to carry out debates and other activities by using different stimuli.

5.3.1.3. Debates conducted by humanities teachers

A variation of debates with multiple perspectives was witnessed in Modern High School, where the focus was on developing debating skills in students.

These skills were centred on elocution, voice modulation, vocabulary building, etc. Therefore, the responsibility of conducting debates was assigned to humanities or language teachers specifically. Science teachers believed that language teachers have the right skillset to develop debating skills in students, and their role should be limited to providing relevant content or topic for the debate.

The process for conducting this form of debate is:

- A science teacher provides the humanities teacher with a SSI-related topic for debate in a particular class.
- The humanities teacher selects 2-4 students to debate. The students are usually selected based on their oratory skills.
- Humanities teacher along with students prepares a written form of debate from multiple sources such as, science magazines, newspapers editorials, Internet. The written debate is prepared from different perspectives such as societal impacts, scientific facts involved, economic consequences, and political factors involved.
- The written debate is sent back to the science teacher for checking the scientific facts in the debate.
- After correction by the Science teacher, these 2-4 students in the class conduct the debate after optional rehearsal sessions with the humanities teachers.
- After these assigned students finish the debate, the rest of the students in the class are asked to briefly present their perspectives about the debate. Later, the entire class is involved and they share their views or ask questions from the teacher or assigned students about the debate.

Paula explained that this form of debate is most commonly used in standards 6th – 8th in Modern High School. She does so as she believes the language teacher has the right skill set for carrying out debates and discussions.

> *"We also have debates and discussions not only in science that are coordinated by our English teacher."[Paula-I2-R6]*

"I think it would be better if you talk to her about debates, she'll be able to give you a better picture. We give them topics, and then we have debates between say, boys and girls. Yesterday, only we gave them a topic, which they should prepare, from home. They're very enthusiastic about such activities." [Paula-I2-R7]

In informal discussions with the language teacher, mentioned by Paula in her interview, it came across that the language teacher sees this as an opportunity to prepare specific students for debating competitions, and it also serves as an informative session for the rest of the students. She also said that certain science teachers, such as Paula, are sometimes present in the room when these debates take place, but the chief moderator is the language teacher herself. She encourages the students that agree with multiple perspectives over SSIs, as she believes there is no right or wrong in these terms.

5.3.2. Rationales behind choosing debates as a method to teach SSIs

A multitude of rationales were encountered during observations and interviews, for teachers choosing debates as a method to teach SSIs. These rationales varied from teacher to teacher, and also varied for a teacher when choosing different topics. Some teachers had more than one rationale for conducting debates. The various rationales encountered are presented below.

5.3.2.1. Debate as a means to develop evidence based argumentation and critical thinking

Developing critical thinking has been observed as one of the common rationale of teachers for the choice of discussion and debates as the teaching methods to teach SSIs. This rationale was encountered while talking to Victoria later in an interview, after the observation session for a debate in her classroom. She revealed that she used different kind of resources to teach controversial scientific issues to allow students to develop critical thinking and the ability to back their claims and arguments during debates with scientific reasoning and evidence. This is

in line with her rationale for using debates as a teaching method, in the first place. She provides them with a varied set of resources to gather information from before taking part in debates. This also helps bring out different students' perspectives of the same resources; for instance, students have different perceptions and arguments about the same video clips. This helps students to analyse and appreciate the different ways of thinking about the same resource and change their point of view in case they feel someone else's perspective fits better. In her interview Victoria disclosed that her choice of debates primarily depends on the age group. She prefers discussion as a method to teach SSIs to junior classes (11-13 years old). On the other hand she prefers using discussion for senior classes (14-17 years old) to empower students by giving them an opportunity to understand the gravity of the problem.

> *"See it depends on class to class. Like for junior classes, the main aim is to aware them and give them a sense of right and wrong, so I just discuss things with them. (. . . .) For senior classes it is more about how they talk about the information they have. I provide them with whatever relevant information or videos are available on net or on channels. (. . .)I just don't stop thinking after the school hours. (. . . .)I keep on thinking about how should I communicate the reality of this problem to students?" [Victoria-I2-R15]*

Later in the interview she added that:

> *"I want them to decide on their own whether they think using pesticide is right or wrong. (. . . .)And it's not about just thinking, they should be able to defend it to. They are our future generation, what's the point of teaching them all this, if they can't think beyond textbooks." [Victoria-I2-R17]*

One of the important points that are adequately outlined in above excerpt is the clarity of her vision. She envisages debate as an opportunity to stir critical thinking in students. She put special emphasis on articulation of student's thinking through argumentation in debates. It can be said that Victoria perceives argumentation as a powerful vehicle to activate critical thinking of students. She believed that this method can stimulate students' intellectual growth, and they will be able to look beyond the boundaries of the textbook. Later she also mentioned that she wants her debates to flow like a genuine conversation, trigger inquisitiveness

amongst students, and motivate them during debates to present their arguments with scientific reasoning. In a similar vein, Jasmine also agreed that the best part of having a debate is when students are able to articulate their opinions and thought-process in words backed with proper evidence.

> *"(. . .) The best thing is they have a mind-set, they have a thought process and you can see it in the class. It is visible there, they question other's opinion, justify their own and that too with proper facts not just like having a foolish argument." [Jasmine-I2-R18]*

5.3.2.2. Debate as a means to encourage students to take informed decisions

This rationale came across in an interview conducted with Jasmine, where she narrated an incident about a debate that she had carried out in her classroom. She provided students with enough resources to prepare for the debate, and when the actual debate began, she took a back seat to let students learn from each other's perspective and to take collectively an informed decision based on their individual information and perspective.

> *"(….) A project on organic farming. (…) some students were assigned the topics like benefits of not using pesticides and insecticides and other the complete opposite so that we have both the scenarios clear. (…) we were sort of debating on this topic(. . .) then the students themselves gave a solution that 'mam if the government fixes a minimum support price for the crops then the farmers will obviously take a risk and try to use other methods'. (. . . .).The best thing was I was adding quite less to the conversation, there were many kids who were giving their viewpoints and were able to justify it themselves." [Jasmine-I1-R20]*

Although this debate session was not observed, from this particular excerpt from the interview, it can be construed that she wanted the students to understand the social ramifications underlying SSIs. According to her students were able to take an informed decision after considering the social, economic, scientific

and political perspective related to the issue. She also added that the students were able to back their claims with required justification.

5.3.2.3. Debate as a means to explore students' ideas and opinions about SSIs

Teachers tend to conduct debates to help students explore their ideas and form informed opinions about SSIs. Hence, they do not tend to choose a completely new topic for debates as they feel students can't bring in their personalised view in that and they rather just copy arguments from the Internet. They try and facilitate, before and during the debates, the students in a way to help explore their ideas about the topic by providing them right resources, choosing more familiar topics, and asking them questions that would intrigue them into exploring their own ideas. Teachers like Katie, purposefully plan to put controversial situations in front of students to counter-question the students' stance of their ethical position. It was observed that when teachers asked counter-question to students, then students were more vocal and expressive.

> *"See usually we test them for technique in the exams (...) then the question comes (...) what do you think are the social and ethical issues related to it. See our job is to teach about scientific technology. We make them talk and debate because we want to know what their perceptions are; we generally discuss things with them. We put situations and questions like that only to understand their perspective, to know whether they are aware, what sort of ethical issues are they aware of. (....) Basically just to know what's going on in their minds. We can't do this through written exams". [Katie-I3-R16]*

5.4. Lecture Method

One of the three main teaching methods that were used by the teachers to teach SSIs is lecture method. Using lecture method for teaching comes under teacher-focused strategy. A lecture-based method is generally characterised as a traditional passive learning method of gaining knowledge (Zakaria et al., 2009). The teacher is the main person in authority and hence plays a pivotal role in teaching-

learning process of the class. For this reason, this method is considered as a teacher-centred method where a teacher dominates the discourse in the classroom. To facilitate the analysis, lecture method can be further divided into two different forms: explanatory lecture and interactive method.

5.4.1. Forms of Lecture Method

On an initial analysis of the data related to the lecture method, two forms of lecture method were witnessed depending upon the level of interaction between the teacher and the students during the lecture. These two forms are namely, explanatory and the interactive lecture methods. In explanatory lecture method, the control of the classroom was entirely in the hands of the teacher and the interaction was very limited or there was no interaction at all. On the other hand, in interactive lecture method, students have relatively more freedom to interact with the teacher, and the communication was essentially a two-way communication. More details about these forms of lecture method have been provided below.

5.4.1.1. Explanatory Lecture method:

This form of lecture method usually refers to a lecture where the teacher tends to explain the textbook content to the students. In explanatory lecture method, the teacher plays a central role where she does the talking for almost 80% of the time and the student interaction is limited to a minimal level (Zakaria and others, 2009). The student-student interaction is missing throughout this method, and the teacher through a short question-answer session regulates the student-teacher interaction. The questions posed by the teacher have a focus on recall of knowledge related to the subject-content, rather than problem-solving or inquiry (Garside, 1996). The teachers only consider the correct answers, and the incorrect answers are ignored (Zakaria and others, 2009), as also observed in our study with Andy. Out of the 14 teachers interviewed and observed in this study only Andy and Kady were following this method more often.

In this study, I witnessed a special emphasis being laid on the teaching of SSIs by explanatory lecture method by one of the participant teachers named, Andy

from Modern High School. He follows a teacher-focused strategy for teaching SSIs and uses textbooks as a primary resource for that. He follows a rather inflexible process in his classrooms for teaching almost all the topics, where he reads out each and every line from NCERT books, followed by an explanation of these lines and eventually dictates the questions and answers simultaneously to students. He makes sure that the students are marking questions in the textbook that he deems important for the examinations.

> *"Listen, what I feel is that there are two ways of teaching. One is lecture method and other is we should read word by word from the books. I prefer the second method. In this method you can mark the question and answer side by side, make them understand the chapter and explain them side by side." [Andy-I2-R8]*

He was observed asking the questions backed with the desire that the answers should be well-versed with the scientific facts and repetition of these facts in the form of questions, will prepare the students from exam perspective. He rolls on the same question through the class till the time he doesn't get a satisfactory answer complying to the facts in the textbooks. This was also observed during the observation sessions.

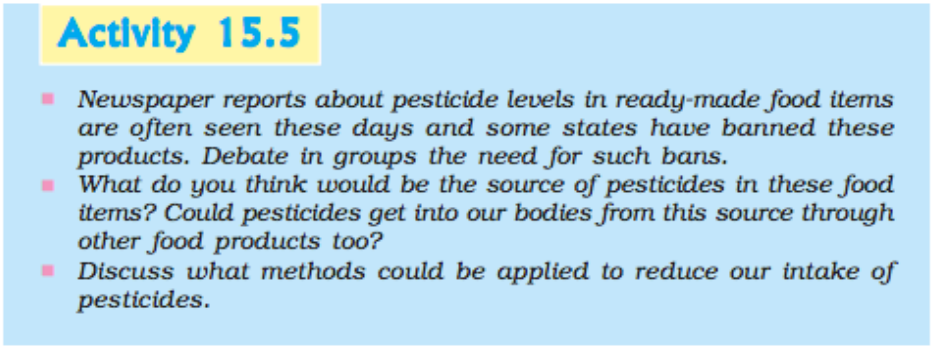
> *"Whenever I finish a chapter in the class, (…) I start questioning from the first row, so the question will keep on passing to the next row and I keep on asking the question through all the rows, till the time I don't get the proper answer. I keep on asking the same question again and again." [Andy-I3-R4]*

Andy's special emphasis on the 'proper' answers is in consistency with the characteristics of explanatory lecture method. Andy purposely repeated the same question to extract what he terms as 'proper' memorised factual knowledge.

Andy's line-by-line teaching method from textbooks is in coherence with his other desire of his students being well acquainted with all the scientific facts. But in terms of teaching the SSIs he focuses on covering the scientific part of it through textbook and the ethical-moral dilemmas or societal aspects involved with such issues are not adequately addressed.

"(. . .) It goes simultaneously almost for all the topics. Nothing special for any particular topic. Like you have observed my lesson, I first explain through lecture method or say explanation method and then I read line by line and make them mark questions and answers." [Andy-I2-R10]

This was reflected in his teaching too, during one of the observation sessions in his classroom. While teaching biological-magnification topic, it was evident that he was primarily concerned about his students clearly understanding the canonical scientific aspects of that topic. He even tried to better explain the scientific content by relating it to the digestive system in humans. He explained that the inability of microorganisms to break down harmful non-biodegradable substances (pesticides, insecticides, etc.) in biological modification is similar to the inability of enzymes in the human body to breakdown cellulose.



Activity 15.5

- *Newspaper reports about pesticide levels in ready-made food items are often seen these days and some states have banned these products. Debate in groups the need for such bans.*
- *What do you think would be the source of pesticides in these food items? Could pesticides get into our bodies from this source through other food products too?*
- *Discuss what methods could be applied to reduce our intake of pesticides.*

Figure 5.1. A snapshot from an NCERT book for a debate activity

Figure 5.1 shows an example activity mentioned in an NCERT science book for conducting an activity with the students. As evident in the figure, the activity was supposed to be a debate. However, when Andy covered this activity in his class, he just delivered the scientific facts, asked questions from students about the scientific facts they learned in the end, but didn't discuss any moral-ethical factors or any implications on society for that topic. During the lecture, one of the students shared her personal experiences what she felt was related to the topic of bio-magnification. He didn't discuss the ethical and moral side of her story and just explained the scientific facts related to it to the rest of the class. On being questioned post class, why didn't he answer the student in the context she explained her story.

He replied, "*I am not bound to answer things beyond science, this is a science class, not a moral science or a political science class. If you will ask me questions about science I'll surely answer it, else not*."

This was strikingly different from what Daisy, Jasmine and few more teachers were observed doing in their lessons. Out of 14 teachers interviewed, 13 of them had acknowledged that they relate the textbook content to the real life situations for varied reasons that have been described earlier in the rationales.

A slightly different angle was observed in Simi's lesson where she was teaching about global warming. Similar to Andy, Simi also followed an explanatory lecture method to teach SSIs; however instead of just focusing on the textbook content, she preferred addressing the contemporary situations while teaching. She was observed putting special emphasis on explaining the textbook content and 'telling' student's about the situations prevailing in the world that are related to SSIs. The word 'telling' specifies a one-way communication where a teacher talk and student listen without any scope of opportunity for the students to present their views. She said that:

> *"Whenever I am teaching these topics (pollution and global warming, I always tell them about the other things happening around just to let them know how much important it is. Whatever I read in the newspaper or science magazines regarding pollution and global warming, I tell them that too. I think telling them is important." [Simi-I2-R21]*

In addition to this, she also told students to discuss the contemporary problems they face and issues they observe in their surroundings with each other in their free lectures, but never showed an impetus to initiate one. She stated vividly, that for a better India, student should be conscious of their environment and should take required steps to curb the growing menace of pollution. While she was 'telling' students what they should do, students listen to the teacher patiently and there was a pin-drop silence in the class.

5.4.1.2. Rationales for using Explanatory Lecture Method

Two main rationales emerged from the interviews of both the teachers who used explanatory lecture method to teach SSIs. These were related to the perspective they have towards examination i.e. the importance they hold for the written examination and the need to maintain discipline in the class. These two are described further in this section:

To prepare for exams. As discussed before under explanatory lecture method, Andy follows a very rigid and rigorous teaching approach for teaching SSIs. For this purpose, he follows textbook religiously. He explains that he chooses this approach due to his teaching goal of preparing the students for exams. He added that:

> *"The reason for using this method is because most of the board exam questions, school exam questions they are framed from NCERT. Each and every single line is important, sometimes the questions are asked from the diagrams or the pictures. We (.....) read every line from the text book, (....) and then I will explain them and make them understand. (…)" [Andy-I2-R8]*

His preference to follow textbook dutifully was because NCERT books are the officially prescribed books by CBSE board for teaching all the subjects in CBSE affiliated schools. On being probed during interviews, he explained that all the exams up to 10th standard (14-15 years old) are exclusively based on NCERT books. Hence, he focuses on dictating each and every line from NCERT books to students, so that they can get good marks in examinations. However, the exams for 11th and 12th standards (16-17 years old) are not solely based on NCERT books. Therefore, he refers to certain extra books beyond NCERT too, to cover all the topics in detail.

> *"See, in NCERT there is basic of everything, many times extra details or say explanations are missing. (…) Students are not clear about the concepts, so we follow other books where proper and extra information is given. We have to follow other reference books for explaining concepts. This also affects their performance in the exam." [Andy-I2-R4]*

The rationale behind this rigorous teaching from textbooks line by line, as inferred from his interviews and observations, is his desire to see his students secure good grades in the examinations; and that they should be well versed with the intricacies of canonical scientific facts they learn during SSIs teaching in classroom.

> *"My personal target is there should be at least 20 students in my class who will be scoring more than 90 marks and at least 10 who are in the race of toppers." [Andy-I2-R14]*

This is also one of the factors that affected Andy's teaching, and has been discussed in detail in discussion of RQ3. He also views that the ultimate purpose of his being as a teacher is to prepare students for exams.

> *"(.....), mostly the questions are from text book and are twisted. They are framed and asked according to the examination perspective. See, we have to prepare the students for the exams basically, (…)." [Andy-I3-R5]*

To maintain discipline in the class. Another, key observation during these sessions was the lack of interaction with the students. This observation was reaffirmed in interviews, where he explicitly mentioned that he uses his method with minimal interaction as he wishes to maintain discipline during his lecture. Less positively, it is found that he refrains experimenting with other method as he assumes that this may cause him to lose his authority over the class. These findings were echoed many times in the data and will be described further in the chapter.

> *"See why I choose lecture cum explanation method along with the marking of question and answer is because then there is very less scope of students creating mess in the class. There is very less scope of students grabbing the opportunity to create indiscipline in the class. (…) We all need a disciplined class to teach, why I should bother, try any other thing when I know it will create indiscipline." [Andy-I2-R26]*

The above excerpt also correlates to his teacher-focused strategy, as he wishes to maintain the control and responsibility of teaching-learning with himself and dictates the scientific facts himself, as he feels any shift in control towards students in form of interaction will disturb the decorum of his classroom.

> *"We just expect them to be disciplined in the class and get good marks. Nothing more." [Andy-I2-R24]*

Hence, he seemed not very keen to conduct interactive activities such as debates and discussions.

> *"So, we are not doing all these debates most of the time because our students are not the students meant for debates. It is risk and is dangerous (laughs sarcastically). Secondly, they are undisciplined." [Andy-I3-R1]*

5.4.1.3. Interactive Lecture method

Another variation of lecture-method is the Interactive-Lecture method. In this form of lecture method, the teacher usually tries to interact with the student while teaching and explaining the chapter to them. Students have more freedom to interact with their teacher and question back their teacher in case of a query. Though, student-student interaction is still limited, the nature of questions asked also varies from that of explanatory lecture method. Instead of being direct canonical scientific facts related questions, the questions asked were focused at gaining answers regarding students' experiences and their previous knowledge about the subject-content. Out of the 14 teachers observed, at times many teachers were found using a combination of this method along with other methods discussed before. This is further described by few excerpts from the teacher interviews. Daisy preferred using this method along with debates and discussions (as discussed before) for teaching SSIs. Along with the textbook, Daisy also used many other different resources like power point presentations and audio-video clippings for teaching SSIs. She uses them in a very flexible manner. She used these for the better understanding of the concepts during or at the end of the chapter, as she wanted students to be able to relate these topics to their lives, unlike Andy who just used this for revision of canonical scientific facts.

"We show them the module, and side by side the questioning is done." [Daisy-I1-R7]

"See, sometimes there are activities, and sometimes there are abstract things which are given in a concrete form in the modules. So after finishing the chapter we show them the module, to make them revise the things, or sometime we show them side-by-side, so it all depends upon the content. I just want them to be able to relate to the things they learn." [Daisy-I1-R8]

This method is different from the discussions in a way that there is almost no scope for students to discuss any issue with each other. Although they are provided with liberty to ask questions to teacher, but whether the question is worth any discussion or not is solely in the hands of the teachers to decide. This is illustrated in the comment below by Kady:

"I keep on asking them (students) questions (. . .) Sometimes students ask questions outside the chapter, so if it is relevant then I relate it to the chapter and if it is not then I just answer their question and don't waste more time on it". [Kady-I2-R24]

Similar situation was also witnessed in a lecture of Simi, where she was teaching pollution and students started questioning her regarding the waste of the crops and how it is disposed by burning at some places. Initially she was comfortable with the questions, but as she remarks students' probe became irrelevant after a certain time and at that time she decides to stop the students there only and get back to the chapter. Later in the interview she explicated,

"*There was no point going ahead and answering the questions that were not related to the chapter. (. . .)Somehow they were related too, (....) there is no need to go in that direction. They are not going to get these things in exam, so why should I waste time". [Simi-I2-R17]*

Since many of the teachers were found using Interactive lecture method for teaching SSIs, they had varied reasons for choosing this method. The following section provides the rationales for teaching SSIs through interactive lecture method.

5.4.2. Rationales for using Interactive Lecture Method

5.4.2.1. To develop interest in the topic

Developing interest of the students in the topic has become ubiquitous in all the methods. In this particular method too, the teachers follow different techniques to foster student's interest in the topic (as also discussed before). Kady was found interacting with students by first giving them real life examples on her own and then asking students about the same. When she recognised that there was not much response from the students, she started asking them questions regarding the observations that student should have made in their daily lives. After that moment, the lecture became interactive as students were seen raising their hands and giving examples of the situations that they have observed. She added that:

> *"I try this so that my students can relate everything to the real life situations. (. . .)If I am teaching about air pollution, then I always try and relate the topic to a local problem or area. This makes students develop interest in the topic and they ask more questions. If I can't respond regarding a particular problem then I talk about their daily life experiences. This time I asked them about black soot particles that they see on their white shirts. (. . .) And they immediately responded that yes they see it*." [Kady-I2-R14]

Jane also believed in making things interesting for students. She wanted her students to be excited about what they learn. To do so, she believes that relating the SSIs content to their own lives works the best for her. Referring to this, Jane added that:

> *"How can you imagine that teaching without relating things to their daily lives will work? It's very beneficial when they can relate, like I was telling about Global Warming and then I told them how it affects our environment, and how we do certain things to change that." [Jane-I2-R4]*

> *"If I am teaching a scientific topic, this is very boring but when I add examples from daily life they become interesting. I can figure out from their eye contact if they're listening and are interested or not. I ask them not to take any*

notes on their books in my class, when there are interesting things that just stay in your memory." [Jane-I2-R5]

It was also observed during her class that she constantly looks for facial expressions and figures out students who might not have understood the topic from her experience. She then explains things in alternate manners, giving more examples from their own lives.

"[My goal is] To make them understand scientific knowledge, make it interesting for them so that it goes down their memory lane forever, beyond class, they should have a wow factor from the things they learnt with me, so that they are excited about the things they learn from me. When I'm watching TV I keep on changing channels, because there's nothing interesting and then I think to myself why should my students listen to me. They're exhausted throughout the day and I need to make things interesting."[Jane-I2-R20]

5.4.2.2. To ensure that students are active in the class

An additional rationale for Daisy for asking questions in the class is that she wants to make sure students are concentrated and understand the content. Teachers shared that this kind of method not only allows them to ensure that students are attentive in the class but also helps in getting immediate response of whether the students have understand the topic or not.

"I keep on asking them questions in between just to see if they're concentrating or not. " [Daisy-I1-R5]

"See we need to keep them focused (. . .) when I do such things [asking them questions in regular intervals while teaching], I get instant feedback if they're listening to me." [Daisy-I1-R41]

Annie also disclosed that she has been following this method from a long time. It allows the teacher with the freedom to try different resources for developing interest of the students in the chapter. It also helps her to make sure that students are active in the class.

"I try visual aids, (....) I try to give them day to day examples that create some interest in some of the students not all though. (...) e.g. I am teaching about environment (...) I will pin point particular student and start by asking questions to the student who is not listening. So then he becomes more attentive. (...)This has been going from long time." [Annie-I2-R12]

Kady also emphasised the need of student getting involved in the chapter.

"I try to interact with them and make them speak more than me. They ask me questions and then I clear their doubts by telling them that yes you are right or whatever the situation is. (….)What is important for me is that they are active and not sleeping in the class." [Kady-I2-R6-7]

5.4.2.3. To make the lesson more impactful

It was also found at many instances that teachers were found talking about the impact of the teaching of SSIs. Exploring more in the word 'impact' reveals that different teacher emphasised on the different facets of SSIs when they talked about the impact of teaching SSIs. Few teachers like Andy and Simi focused on the recall of factual knowledge more and replicated the same ideology in their choice of teaching methods too (as discussed before). Some teachers like Kady focused on the impression that SSIs create on students' minds. Rather than giving instructions (i.e. giving explanatory lecture), Kady preferred striking a chord with the students so that they get the room to question her back. She feels that in this way students are not only contextually sound but also get an opportunity to clear their doubts. This further help the students to have a lasting impression of what she terms as 'right' or 'wrong' side of SSIs.

"I don't believe in giving instructions. I tell them the reason behind the don't, so why we should not do this and I allow students to question me, if they don't understand it. I think this is more impactful, at least the impact is there for a longer period, than what you get from just telling them through lecture." [Kady-I2-R10]

5.5. Other Activities

A range of other teaching activities, apart from Discussions, Debates and Lecture-Method, have been identified that teachers used for teaching SSIs. Although debates and discussions can also be termed as activities, are perceived differently than 'other activities'. The features differentiating these other activities from debates and discussions are that: a) Most of these other activities are pre-planned by teachers and school authorities at the beginning of an academic year. However, debates and discussions are not a part of any pre-planned academic calendar, and are rather dependent upon a teacher's personal choices; b) Since most of these activities are pre-planned; hence they are usually not a part of the regular teaching-learning process. They usually have separate slots allocated for conducting, than regular lectures. Debates and discussions on the other hand are carried out along with regular teaching of lessons in the classroom, based on teachers' personal prerogative.

An example of 'other activities' was witnessed in Rockford School in a 5-day event called Mathematics of Planet Earth (MPE). UNESCO declared a year of bio-diversity, and authorities of Rockford School along with Victoria decided to choose UNESCO's theme for their yearly events. They prepared a pre-planned calendar of events around this theme. MPE was the biggest events of the year that was planned, and included a national level inter school competition on various activities revolving around environment, such as global warming, pollution, and climate change and included some SSIs too.

These pre-planned other activities, also frequently termed as 'co-curricular' activities in various schools, have been classified in two forms based on the observation data, namely in-class and outside-class activities. In-class activities were carried out within a classroom during observations (e.g., role playing), and outside-class outside the classroom, or school (e.g., field visits). The classification of these activities has been discussed in detail further on. In-class activities were more frequent than outside-class activities because of the comparative ease in conducting in-class activities, as most outside-class activities required a preparation phase, and taking permissions. Hence, as Katie suggested they would take up in-class activities more frequently than outside-class activities.

"Generally, we take up one or two of the projects [referring to outside class activities mentioned in textbooks] mentioned not all of them. And about activities to be conducted inside classrooms, we do them when we visit labs." [Katie-I1-R2]

The involvement of teachers in these activities is generally decided upon certain specific skills, or background of a teacher. For instance, in Modern High school both Annie and Nancy were teaching similar subjects, but Nancy was chosen to conduct street plays activity. Nancy mentioned that due to her previous background in handling and performing on stage, and her confidence in conducting dramatics-related events is the reason she's assigned such activities. Similarly, in Rockford school Katie was responsible for managing poster, collage or banner making activities, due to her inclination towards the aesthetic quality of the outcomes of such activities. In certain schools such as Queens High and Blue Bells, the involvement in such activities was just imposed upon the teachers by the school authorities. The details have been discussed as one of the influencing factor in the discussion of RQ3.

5.5.1. In-class activities

The activities chosen under In-class activities were conducted within the classrooms or had the maximum work done for them in classroom, and were mostly pre-planned. In-class activities, amongst others, include role-playing, poster and collage making, and scientific projects.

5.5.1.1. Role Playing

Role-playing as the definition "behaving in accordance with a specified function" (Dictionary, 1989) suggests, is used by teachers by assigning specific roles to students where they imitate certain conditions, and pretend to be something. The rationale for using role-playing as an activity is to help students realise different perspectives related to an issue by trying to simulate conditions related to that issue.

Jasmine conducted role-playing in her classrooms to teach effects of greenhouse gases on our environment. Jasmine meticulously designed this activity

that involved both concept learning and covers the social & ethical aspects involved around this topic. The knowledge about various gases and their properties cover the concept learning. In the next phase, she used the concept learning to discuss the social & ethical aspects of the topic while discussing past and future aspects. The interactive learning process involved in this activity, made students feel engaged and they were able to go beyond the textbooks to even relate to the real-life incidences in the past. This also shows that the teachers tend to pre-plan the activity to fulfil their objectives using such activities. In this particular case Jasmine had pre-planned the activity and was looking forward to cover the concepts and social and ethical facet of SSIs through a single activity.

> *"(. . .) Like we have this topic of Greenhouse gases and global warming. So I form groups of main greenhouse gases like carbon dioxide, (. . . .) and students in each of this group tries to gather information of the gas they are assigned, which include things like emissions, causes, consequences and what can be done to prevent their emissions. After this two groups are formed one which talks about the past and the other which talks about the future. In this way students add their knowledge also and their opinion also. Sometimes students ask, (questions) (…) And then you can see how students are able to link pollution to global warming and then to climate change. (….) Students always go beyond textbooks; they research their assigned gas properly. Not only this, they know the properties also of all the gases, which is not even in their syllabus. I remember once, we were discussing this in the class and a student asked that "mam I came across the Bhopal gas tragedy, was it a Greenhouse gas". So you can see that it does not matter it is in their syllabus or not, but they are quite inquisitive about all this. They do it with full zeal; they want to be better than the other group." [Jasmine-I3-R16]*

The rationale behind using this activity was that according to Jasmine students get both physically and intellectually involved in the activity, and students are able to express their ideas in a scientific context. This also helps them to understand the concepts related to the topic using their own experiences, and peer learning.

5.5.1.2. Activities for pictorial representation of SSI issues

The second activity in in-class activities is related to drawing pictorial representation of students' ideas and knowledge about SSIs. This includes drawing posters, collages, or banners for awareness about SSIs in people. The students are generally given a topic, and they research the topic on their own and draw a pictorial representation of it. This activity was highlighted during special events in various schools. In Mathematics of Planet Earth (MPE) event this activity was generally assigned to lower age group students. The details of MPE-related activities have been provided further on. The resulting example pictorial representations collected from special events have been added in Appendix-F.

5.5.1.3. Paragraph writing

The third activity in in-class category is paragraph writing. In paragraph writing teacher assigns a SSIs-related topic to students to gather information about and write a paragraph on. The role of a teacher in this is to assign a topic to students and check the final writings of students for possible inconsistencies. This activity was only conducted by Paula, and was conducted in an interdisciplinary fashion. She coordinated with an English language teacher and asked her to actually conduct the activity, and Paula just assigned the topics to the students. This is similar to the way Paula assigned debates to language teachers. Her rationale behind doing so is that she believes that literature teachers have better skills to conduct such activities and can help students more. Hence, she believed that such a cadre of activities involving social, moral and ethical aspects should be the responsibility of humanities teachers, and not Scienceteacher.

"We give them environment related topics for paragraph writing too in other subjects." [Paula-I2-R2-3]

5.5.1.4. Paper Reading

The next activity in in-class category is paper reading, which refers to an activity where students gather information about a SSIs-related topic and read out the information in front of an audience. Subsequently, teachers add some information to the material read by the students. The role of a teacher in this activity to ensure that the

information being read out by students is correct, has the right tone, and gives a clear picture of the society outside school. The information read out by students could include plain facts about the topic, their own views on the topic, some editorials from newspapers about that topic, etc. This activity was done by teachers to ensure that information regarding contemporary issues is made accessible to a larger set of students. This activity was observed in Rockford and Modern High Schools with Katie, Victoria and Paula.

> *"We give different topics for different classes. We also give topics for paper reading, debates. In paper reading, they collect the information on a topic and present it. There they have environment related topics, such as, use of plastics. We keep on giving them topics, not only in science." [Paula-I2-R2-3]*

Paula followed a similar approach like paragraph writing and only assigned topics for paper reading and a language teacher conducted the actual activity. In Rockford school, on the other hand, chose paper reading as an activity for making students aware about contemporary SSIs. Their rationale to conduct this activity was that they believed students should be well acquainted with the contemporary SSIs to become informed citizens. Hence, each day a student was assigned to read out their paper on a contemporary SSI in Intercom during morning assembly. The assignment of topics and the choice of students were done by Science teachers Katie and Victoria.

5.5.1.5. Projects

Another activity used by teachers to teach SSIs is development of scientific projects with students. Scientific projects require students to work together on a practical problem in team(s) to achieve an intended outcome or solution. Teachers' role in this activity was to come up with ideas for projects, managing resources and appropriate permissions for the implementation of projects, and guiding students throughout the duration of projects. The intended outcome of projects vary from making students strengthen their conceptual knowledge about SSIs, sensitise students towards moral and ethical aspects involved in SSIs, gaining insights into informal reasoning of students' minds and developing it, develop data collection and analysis skills in students, making students realise the importance of evidence in

science, and preparing projects for competitions. The projects have been categorised in two different forms, namely Field-projects and Lab-projects; based on the location of the execution of projects. These projects do require data collection from outside the class, but the major discussions and planning is done within classroom between students and teacher. Hence, this activity has been placed in in-class activities.

Field-Projects. The objective and the choice of the projects are also inextricably linked to the maturity level of the students coupled with their conceptual knowledge about the topic. This was corroborated in a project initiated by Katie for 15-year-old students. She initiated a project related to a contemporary issue, i.e., pollution of a local lake that has emanated from the society students live in. The choice of the project and its tasks was done keeping in mind the age group of students and the conceptual knowledge they currently have about the topic. Hence, she chose 10th grade students for this project where students had to find out the impact of growing pollution on the surroundings of a local lake.

> *"(. . .) I myself coordinated and supervised a project that was meant for class X regarding the cadmium toxicity in the soil and water near the [local lake]. Our students found that the cadmium is a heavy metal and it traps in the plant (…) there is a lot of crop production and fisheries production. (. . .), people are consuming it almost daily and our students scientifically proved it with the help of ****University authorities. . It (. . . .) is really harmful and toxic and is having drastic effect on our health. (….)."[Katie-I1-R6]*

Before the project began, Katie did a good amount of comprehensive review of research and accumulated all the microscopic details regarding the problem in hand. In tandem with the information collection, she managed necessary permits from the school authorities and collaborating **** University for conducting chemical tests required for the validation of the students' findings.

Katie's motive behind this project was to raise ethical and moral awareness in students and sensitise them towards societal impacts of pollution. She followed a path of scientific procedure for achieving that motive. She subscribed to the scientific method of exploration, observation, testing, experimentation,

evaluation and analysis to let students analyse and understand the situation on their own. Katie adequately outlined her role as a teacher and the students' boundaries. Though she acknowledges the fact that the socio-scientific issues (like the above example) are prevalent in the inner sanctum of the society and it is her responsibility as a teacher to evoke a social conscience in the students, she averted students' actions to formulate the implications of their reasoning beyond what she terms as their 'limit'. This happened when students wanted to take some action based on their collected data, and contact state government regarding the problems and offenders; but Katie did not allow them to do that. In this situation Katie transited from one strategic plan to another. This is a suitable example of a transition of a teacher changing her strategy from student-focused strategy to a teacher-focused strategy.

> *"We as teachers and the students also, can take initiative and can just raise the voice. My students were so involved in this project that they "actually" wanted to do something. I personally feel that our job is done; we had a project, found the problem, proved it with facts and figures and raised our voice. Some of my students wanted something more (. . .) ask the government to give them [factories] warnings or ban it if they don't stop all this. But after a point I feel that I don't want my students to be a part of a social controversy and that too like messing around big people. So I just told them that this is not we are meant to do. According to the education perspective our boundary line is this, and we can't cross it." [Katie-I1-R6]*

During the course of project, when Katie felt that students have understood what she desired and her job as a teacher is done; she decided to draw a line, and stopped the activity and also told students that the activity was over as any further action was beyond the bounds of a student activity.

Subsequently, when Katie felt that students were disappointed at lack of action from the results of their project, she asked her 10th and 11th standard students to watch a video that presented global warming from an alternate perspective. She wanted them to understand the entangled cords of science and society and there are certain social ramifications of actions. She wanted them to

appreciate multiple facets of a SSI issue, and form their own opinions after watching these different perspectives. When probed about her intentions behind initiating these projects she explained:

> *"(. . .) When we teach these things in the class then they learn it and may be understand it but just on the superficial level. They don't take it back home in their heart. They learn it, understand the logic, sometimes discuss it, write it and forget it. This kind of teaching doesn't give them a sense of responsibility or say, like the feeling that 'yes' this is our world, we have to do something. I have myself seen that if we teach them this in class they don't give an extra effort. (….)Here it is the teacher's moral duty to make them realise that this is something crucial and I tell you student's at this age are full with energy, if you show them the direction, they are like so passionate that they will find the way themselves. You just need to be there and make them realise what is their role." [Katie-I1-R12-13]*

From the above comment, it can easily be construed that Katie's rationale behind initiating these projects is intertwined between her perception towards SSIs and her personal teaching goals (which will be described further in RQ2 discussion). Her objective behind doing so was that she wanted her students to be informed citizens, wanted to develop their informal reasoning based on evidences and widen their range of rational thinking by this, which they would not have learnt from textbooks.

Lab-Projects. Jasmine also undertook a project on producing Bio-Diesel from natural resources in their school laboratory. Jasmine's had a research background, and is thus interested in initiating research related projects.

> *"So we prepared bio-diesel in the labs, (. . .) Jatropha plant, it's a plant from which we can extract diesel and this diesel is eco-friendly. It is having zero percent pollution and no greenhouse gases are emitted. (. . . .) is a very costly plant, it is an oil seed plant. So we prepared the bio-diesel by Jatropha plant and also with the used refined oils. (. . .) See in India, there so many roadside small*

restaurants (. . . .) so we collected the left over oils from various restaurants and then we prepared bio-diesel from them in our school lab." [Jasmine-I1-R5]

Her motivation behind initiation of Bio-Diesel project was the increasing pollution levels in their city, and she wanted students to realise the importance of alternative solutions for these problems. She formed a team of a few students to work in this project from Grade 9th. She collected all the relevant information beforehand, but let students also contribute towards the final plan of the project and the actual execution of it. She gave a lecture in the classroom, where she explained the need of such alternate solutions given the current environment related issues, such as pollution, global warming and climate change. The project finally became part of a national level competition, and then the participant students were involved to write a report on the motivation and execution of their project. She also took students for a field visit to a local factory to try out Bio-diesel in electricity generators.

*"There is a project making competition organised (. . .) by department of science and technology, Delhi. They organise such kind of competitions every year (. . .) this year, there main theme was energy conservation (. . .). Every two years they change the theme. 5 students were already a part of this project; (. . .) I did this project with senior level students. This was actually a research based project. It's simply like a small mini-thesis we have to write and they have to do a research on a topic and then the scientific solutions have to be given in the end. So for this project we conducted a survey like there are many diesel vehicles in ****, so we prepared bio-diesel and asked them to use it. But initially there was reluctance, so there is a huge factory (. . .) and they agreed to use it in their generators. There was no pollution and they were amazed to see it. But now it's all over, students (.....) got the awards and the medals and now it's over." [Jasmine-I1-R6]*

She mentioned that initially students did not show much interest in the content of the project. Initially, they were just interested to do something beyond classroom lectures, but as the project progressed their interest grew in it.

"Initially they enjoy the activities. But later on when they understand the objective behind the activity, it becomes informative also and it interests them also." [Jasmine-I3-R2]

"(….) And the thing is even students become passionate towards the same (….) I was working on the bio-diesel project they are much more passionate (. …). Now two of them are planning to change their stream to humanities, but they are still so passionate about the project that they had a word with the principal mam to continue with the project and I really feel good about that. (….)" [Jasmine-I1-R12]

Eventually, when students were really interested in the project they wanted to take it a step further and even contacted few oil companies from Dubai, Germany and USA.

"The best part was that the students involved in our research wrote an email to the different oil companies across the world. And one of the companies in Dubai was very interested and he was ready to fund the project only on the condition that if we had the proper labs. So it was in US also and one of the companies in Germany also responded to us. So, we tried to put a lot of effort but again we have a system, now the exams are going on but I have promised the students that we are going to continue this in the next academic session also. The response of the companies was really positive; they also gave us alternate ways to make bio-diesel like from algae in the ponds. They say that you can make an algae pond and extract the oil from them and make bio-diesel and one of the persons is ready to fund the project, so let's see." [Jasmine-I1-R9]

5.5.1.6. Quiz

Quiz is another activity identified as being used for teaching-learning process for SSIs. Only two out of 14 teachers in data collection phase used quiz as an activity. The process of this activity involves splitting the class in teams, and asking questions from them about a pre-decided SSIs-related topic. Teacher's role in this activity is to declare the topic of quiz in advance and prepare a questionnaire for the same, so that students can prepare from the textbooks and also gather general information about the topic from other sources. During the activity teacher asks the

questions, and keeps a score between the teams. The two teachers using this activity were Paula from Modern High and Kady from Blue Bells School. The process of carrying out quiz activity has been described in an excerpt from Kady's interview:

> *"Sometimes we do an activity rather than doing debate. I divide the class into two groups and take a quiz. In this way they prepare for the test also and I tell them in advance that I will ask general knowledge questions also regarding the same topic. So students gather the information, prepare for it and take part in quiz. I also give them scores and declare the winning team in the end."[Kady-I1-R7]*

> *"We promote the ideas like not to waste paper, not to waste water. We also have these quizzes with students; we try to teach them topics in interesting manner. Then we select teams, sometimes students are selecting their own teams."[Paula-I2-R6]*

Paula used quizzes in the classrooms to gather interesting facts about the topic. She jotted down these interesting facts answered by students during the quiz and followed up quiz with a brief discussion among students about the facts she gathered.

The rationale of these teachers for using quizzes was to garner interest of students in the classroom with a competitive activity. Teachers were able to reiterate the scientific facts related to a topic, and believed that this would help them retain facts for a longer period.

5.5.1.7. Presentations

Another activity observed during data collection phase is presentations by students on SSIs-related topics. Almost all the teachers observed did use presentations for teaching SSIs, but one of the exceptions to that is Katie as she encourages students to give presentations on SSIs-related topics instead of teachers. After she was finished teaching her part of the curriculum, she asked students to give presentations on these topics. The key thing was the extent to which students portrayed the scientific knowledge related to SSIs, and the majority content was related to the conceptual understanding, with various cause-effect relations and

science behind them. The ethical, moral and societal aspects briefly touched upon were not much discussed during the presentations. Her motive to do this activity was to improve conceptual understanding of scientific facts in students. Students used various resources such as extra science books and Internet to prepare presentations.

> *"For example there are some activities like go on Internet and find more sources, which are depleting ozone layer other than CFCs, then we give it to students as homework, and they have to give a presentation on that. So we divide whole class in 4-5 groups and each group can present their work. So we're done with in one period with 4-5 presentations." [Katie-I2-R4]*

Another rationale for asking students to make presentations according to Katie was that she wanted to stimulate intellectual growth of students with better understanding of those topics. Students were able to gain insights into multiple perspectives of the same topic through research on topics and peer learning during presentations. The intellectual growth of students was possible because not only students were able to interpret the knowledge on a topic beyond textbook, but also conceptualise into their own way. They were able to select the data relevant for them and were able to represent that in the form of presentation.

> *"For example, there are many sources, which deplete ozone layer, which books mention. So through these projects students come to know about other sources, and they're able to see multiple perspectives of one thing which teacher may not be able to teach. So they get additional exposure and get to know all the causes. Moreover it has a visual and audio impact on students" [Katie-I2-R5]*

Moreover, Katie felt that this gave them a sense of ownership and they were able to relate to it in a better manner. This helped them retain the concepts for a longer period and was an effective activity. The effectiveness of the activity was evident with the performance of students in exams on questions related to these topics.

> *"When students do something on their own, then they're more interested because of the competitive spirit. (. . .) Students try & incorporate as many things as they can and to make their presentations better in competitive*

spirit they learn more. Moreover when they do it on their own, they listen it more carefully because it's their own creation. Therefore, this is always the better method of teaching than just teachers teaching. And the topics on which the projects or presentations are made, students do well for them in examinations." [Katie-I2-R6]

5.5.2. Outside-school activities

5.5.2.1. Special Events

During the process of data collection, three specific events stood out in different schools that involved environmental SSIs based activities on a large-scale. These involved students from grades 6th – 10th and all three events were highly publicised in local media. The first event, Mathematic of Planet Earth (MPE) in Rockford School was a 5-day event involving a national level inter-school competition conducted based on UNSECO's theme on bio-diversity. The second event, Green walk was organised by Blue Bells School. This event was an awareness walk through different areas of the city by students clad as trees, flowers, and the rest in green clothes on topic, Harmful effects of increasing pollution on our climate. The third event, Earth Day, was organised by Springdale School in which the posters for creating awareness about global warming, pollution and climate change were displayed throughout the school. This event included a tree plantation drive, where each student planted a tree in the school premises, at their homes, or in authorised public areas.

Mathematics of Planet Earth (MPE). Mathematics of Planet Earth (MPE) was an inter-school competition involving activities such as street plays, poster making, collage making, banner painting, and debates. Some of the activities have been previously discussed in in-class activities, but MPE specific details about these activities have been provided here. Both teachers and students were involved in preparing for the activities for this event. Teachers along with the person in-charge of this event, Victoria came up with various themes and corresponding activities of varying complexity taking into account for students of different age groups. The lower age group students were given tasks to prepare pictorial representations such as posters, and the higher grades were assigned declamation contests or street plays. This

opportunity gave students a large-scale platform to express their views about environmental SSIs, and learn from the experiences of preparation and participation in this 5-day event.

Grade 6th (age group 11) students were assigned a theme of "A planet supporting life", and were asked to decorate all the intersectional display boards in the entire school corridors. The students were free to choose a specific topic, within the theme, in consent with their class in-charge, and each section decorated around 5-10 such display boards sized (50 in * 70 in). Students collected all the relevant information for the selected topic from their textbooks, science teacher and Internet, and painted or collected images depicting their respective topics. Each section presented their display board contents first to the internal audience and discussions related to that. And later, they decorated the all the corridors in the school, and they presented their display boards to the visitingaudience.

Grade 7th students were assigned a theme of "A planet organised by humans", and participated in the collage making contest. The theme-included topics related to use of renewable and non-renewable sources of energy, political, social and economic aspects of environment related human activities. Students were asked to select a topic, related to the theme, in groups on their own and prepare a collage explaining their view on the topic. Initially, an internal discussion session was held where all the groups presented their collages and discussed the findings with the internal audience, including various teachers and other groups. Each discussion session for a group lasted around 30 minutes. Eventually, during the event these groups competed with the external participants for a half-day contest where all the groups presented their collages to a jury comprising of environmentalists, and social workers. During this activity, the students presented their collages and were questioned about the findings and then a general discussion of around 5 minutes was done amongst the audience about the topic.

Grade 8th students were assigned a theme of "How to protect the planet Earth" including topics such as, "Reduce Carbon Emissions", "Climate Change", and "Reduce Global Warming". The activities were all awareness-related and the

students were expected to select a relevant topic and conduct a group discussion in an interesting manner, with the audiences. Students formed groups in each section and prepared the topics by writing poems, directing plays, satirical street-plays, or in the form of mimes just using actions and placards. During the MPE event, each group presented their topic in an artistic manner and tried to make it as interesting as possible. For instance, one of the groups prepared a satirical play where a student role-played as mute earth and tried to showcase atrocities of global warming on mute earth. After each such performance, there was a group discussion held where people shared their views and experiences about the topic. After looking at the response of the audiences towards some of the acts, Victoria selected some of them to be performed outside school. These acts were then performed in public auditoriums of the city, and the street plays were performed inside shopping malls to raise awareness about the topic in the general public.

Grade 9th students were assigned a theme of “A planet at risk”, and were supposed to draw large posters on their choice of topic, related to the theme. Some classes made really large-scale banners for display around topics such as “Holding hands together for sustainable Earth”. These banners were put up at the entrance of the school before the event, and also at the spots where all the events were organised. Victoria also arranged a campaign with students at a local river at the outskirts of their city. This campaign was against the growing pollution in that river. The banners prepared by students were used during this campaign, and was duly covered by the media aswell.

Grade 10th students were assigned a theme of “A planet to discover”, and participated in time-bound competition of painting captions or short messages on cloth. Students w e r e asked to paint their ideas about topics related to this theme on a piece of cloth within a given time slot. This was an inter-school competition with participants all from 10th grade from different schools across the nation. Then after the preparation time was over, each group presented their slogan, the meaning behind it, and the link between the theme and their slogan. Student groups received some feedback (related to topic) on their discussion from the jury. The feedback included the comments such as explaining the links that students missed while

explaining their slogans, the alternate way of linking their slogans, in-depth knowledge about the topic in question, etc.

Additionally, certain students from all grades were chosen to perform street plays on topics relevant to the theme of the event. Students prepared their street play with Victoria and another teacher responsible for dramatics in advance. Street play, as also mentioned previously in context of activity of Grade 8th in MPE, is a form of role-play activity where students presented the issues concerning environment in a satirical way. During the preparation phase, Victoria helped students write a script for the street play that involved forming satires from the recent and local environment-related problems and events related to pollution and climate change. Students also gathered information from other sources and gave their inputs while the script was being written. Victoria's role was to help students understand the ethical and moral dilemmas involved in the topic so that they can sensitise with the issues before enacting them. Other than that she helped finalise the script in a way that it included the conceptual knowledge related to the topic, and would also have an impact on the audiences. The dramatics teacher took care of the enactment part of the play and assigned different roles to the students. One of the observed street plays was themed "Ganges – today and 25 years ago". Ganges is a holy river in India, and the pollution level has been constantly rising due to the industrial waste, waste from religious activities being dumped in it. Students enacted Ganges – 25 years ago, other students enacted a present day Ganges, a few industrialists, priests, common people who are impacted by pollution, and some students enacted future generations.

Green Walk. Green walk event was organised by Blue Bells School, and initiated by the school authorities on Environment day. This event was not a very large-scale event like MPE and was limited to a few students from grades 6th – 10th. In this event, all the students were clad as flowers or trees, or other students wore green clothes and held posters, banners, and placards with slogans related to environmental SSIs. Students prepared for this event, weeks before the walk. The activities involved in this event were poster making and two street plays on the topics "Stop Pollution Save Earth" and "Join the Revolution, Stop the Pollution". This also included a mobile board where students and audiences on streets could write their messages about environmental issues.

In Green walk, mainly humanities and arts teachers were involved, and science teachers interviewed viewed this more as an obligation. They also felt that this event did not create any long lasting learning opportunities for students.

> *"See we cannot keep and motivating students again and again. These types of events are meant to create awareness, but it's hectic for us too. I am not an art teacher, and neither am I good at it, still I have to do all this. See the event is for one day but the preparations start before only. The humanities' teachers are involved in the rehearsals of the play, and we have to finalise the script and do the selection of students too, all this is too much. I don't have whole year to spend on all this. I have to finish my syllabus too." [Simi-I1-R5]*

Earth Day. Springdale school authorities organised "Earth day" event on National Tree-plantation day in India. This was a school-wide event where students prepared posters and pasted them all around the school. The theme of this event was the importance of trees in our environment, the problems created by increased pollution and climate change. Later in the afternoon during that day, students planted a tree each in the school premises, some students brought their pictures of trees they planted at their homes, and some trees were planted in an authorised public space. A few speeches were prepared by certain chosen students to present their views on the increased levels of pollution and effects of climatic changes. The pictures from the event have been attached in Appendix-F.

5.5.2.2. Field Visits

Field visits, is another outside-class activity carried out by teachers for teaching SSIs. Field visits or Field trips are defined by Krepel and Duvall (1981) as: "a trip arranged by the school and undertaken for educational purposes, in which the students go to places where the materials of instruction may be observed and studied directly in their functional setting: for example, a trip to a factory, a city waterworks, a library, a museum etc." As per Orion (1993), field visits should be conducted in early stages of teaching-learning process, and should focus on concrete activities that are difficult to be conducted in classrooms. Teachers that used this activity, in this study, highlighted the importance of direct experiences of students with concrete problems, phenomenon, and materials. This helps students gain a

clear understanding of concepts that can only be explained in an abstract manner inside classrooms. School authorities play a major role in activities such as field visits, as they need to approve such visits and manage appropriate permissions to conduct visits from the site of visit.

Jasmine took her students for a field visit to a research laboratory in a university for letting students have a clear understanding of DNA extraction.

> *"I took them to the genetic engineering lab, I showed them the entire thing including how the DNA sequencing is done, how DNA Extraction is done and amplification is done. So once I showed them, it was very easier for me to make them understand the topic and I even gave them a project on the same topic." [Jasmine-I2-R5]*

This clearly shows that the teacher was quite confident that the field visited has supported her teaching in a positive way. This made her delve more into the topic and she gave extra assignments to the students. These visits were focused on clearing the scientific concepts of students, especially for the topics students didn't have much previous knowledge about. According to Jasmine, gaining conceptual knowledge about such topics would've helped them understand them better in classrooms. Victoria's campaigning activities with grade 9th students in MPE can also be partially termed as field visits, as she wanted the students to go on the polluted site and see the situation by themselves before campaigning against it.

Katie was quite involved in undertaking projects outside the school premises. She organised a field-visit for students to a local village to help them understand the influence of washrooms near the waster bodies.

> *"(. . .) Our students went to the villages (. . .) I did a project on "Influence of washrooms near the water bodies" (. . .).Students went there and spread the awareness (. . .) See that particular village had a very bad drainage system, normally villagers use hand pump in their houses and they don't have proper washrooms. Because of that they go near the rivers and there is a lot of faecal contamination of the water bodies which further results in various diseases. We again involved **** University in our project; (. . .) our follow up*

showed that the changes were there. Initially, we faced some kind of awkwardness on their part. (. . .) but we did get positive results which boost our morale. So see, we are doing our bit, people are perceptive, but at a larger scale the government only can do something." [Katie-I1-R7]

Katie 's rationale for this visit was that she wants to encourage students to develop their own understanding of such topics, and help trigger a thought process to understand the issues, the dilemmas attached, and the various perspectives. She tries to facilitate them with appropriate resources to do so.

Chapter 6 Factors impacting the teaching of SSIs

To gain a deeper insight into the characteristics of SSI-related teaching practices, one needs to clearly identify and understand the factors that influence these practices. The previous chapter outlined the findings of one aspect of these practices, i.e. the teachers' rationales behind selecting the activities and strategies for teaching SSIs. The current chapter reports on a number of factors that, based on the analysis of the data in this particular study, influence the teaching of SSIs. Since, teachers' rationales are often related to teachers' teaching goals, and goals can have a significant influence on their teaching, there is some overlap between this chapter and the previous one. However, to avoid any significant repetition between the two chapters, teaching goals have not been specifically discussed in this chapter.

6.1. Introduction

The initial findings that emerged from the data analysis in this chapter hinted at a significant level of overlap to the existing findings (Goodson, 2003, Ryder and Banner, 2013). Hence, the findings in this study build upon Ryder and Banner's classification of factors into personal, internal and external contexts. On a deeper analysis into the factors in this study, it was clear that although the individual factors map to Ryder and Banner's findings, there is also a significant level of overlap and interactions between personal, internal and external factors. Hence, it was not appropriate to categorise the factors under personal, external or internal contexts. The factors that are closely related to the personal context of teachers are presented first, i.e., teachers' beliefs and teachers' identity. These factors are followed by factors that are related to the internal context of institution or teachers' department, i.e., school leadership, teachers' authority, student response, pressure of high attainment and resources. Following these, are the external factor i.e. the assessment system, and finally some additional factors are discussed. These additional factors comprise of certain generic factors that have an impact on science

teaching in general, e.g., time constraint, vast curriculum. However, only the aspects relevant to SSIs are discussed.

The focus of this chapter is on the features of the teachers' experiences that have a long term or a significant impact on the teaching of SSIs. The focus is not a minute level analysis of the classroom teaching. The emphasis of the factors delineated is on higher-level factors that impact the teaching of SSIs rather than reporting on the detailed discussion on teaching in the classrooms or the common everyday decisions made in the classroom setting. Moreover, there are some overlaps between different factors impacting the teaching of SSIs, such as students' response, and teachers' beliefs about students. However, the intention is not to draw clear boundaries between influencing factors, as the influence is not always clearly due to a single factor, and can rather be due to interplay of various factors. However, the main influencing factors have been discussed in this chapter, although the degree of impact might vary for different factors. Table 6.1 shows the different influencing factors discussed in this section. As mentioned previously, these factors are an outcome of the data analysis of the interviews and observations data in this study and a majority of these factors are common between Ryder and Banner's framework (Ryder and Banner, 2013). It must be noted that all factors in Table 6.1, except Teachers' Authority are classified under individual sections in this chapter. Teachers' Authority has been classified as a sub-section under School Leadership, as the school leaders are responsible for conferring authorities on the teachers. However, teachers' authority is listed in the table below as it is one of the few factors that is directly associated to the degree of autonomy teachers exhibit to teach and plan their lessons. It is included in this table as it is concerned with the decisions a teacher takes to teach and plan SSIs within a classroom setting which further affects the overall teaching-learning process of the classroom. In no way does it discredit the importance of other factors that have been listed in the following table.

Table 6.1. Factors Influencing the Teaching of SSIs in my study.

Teacher Beliefs
Teacher Identity
School Leadership
Teachers' Authority
Student Response
Pressure for high attainment
Resources
Assessment System
Additional Factors

The teaching methods and the rationale behind the choice of these methods have been covered in the previous chapter. In this chapter, the focus is on delineating the underlying factors that influence these rationales and the teaching of SSIs directly or indirectly.

6.2. Teachers' Beliefs

Teachers' beliefs have been widely studied in many different and diverse domains, such as medicine, sociology and anthropology (Pajares, 1992), and are considered to be the lens through which the teachers perceive, interpret, and respond to external information or situations (Fairbanks et al., 2009). The notion of teachers' beliefs can encompass a wide variety of concepts, making it difficult to clearly define teachers' beliefs. The study of different aspects of beliefs in numerous domains augments the difficulty to have one concise definition of teachers' beliefs (Pajares, 1992). Bryan and Atwater (2002) try to build a general consensus from these varied pieces of research, for a working conception of the term *belief* in the educational domain. Beliefs are agreed to be psychological constructs in a persons' mind that he/she feels are an eternal truth, with some beliefs remain unaltered in a teachers' mind irrespective of the situation they are in (Kagan, 1992, Richardson,

2003, Roehler et al., 1988). The beliefs are formulated over the entire lifetime of a person from all the personal, episodic and emotional experiences (Nespor, 1987). Goodenough (1963) explained that beliefs are a primary determinant that drives one's actions, decisions and judgements. The beliefs that guide teachers' teaching-related actions, and their perceptions about their role as a teacher have been termed as *educational beliefs* (Akkerman and Meijer, 2011, Pintrich, 1990). Educational beliefs concern teachers' beliefs about the subject matter, students, roles and responsibilities of teachers, teachers and teaching methods (Brickhouse, 1990, Cronin-Jones, 1991, Gallagher, 1991, Munby et al., 2000, Tobin and McRobbie, 1996).

Nespor (1987) postulated that a teacher's belief system has a substantial impact on classroom teaching and teachers generally rely upon their educational beliefs instead of their academic knowledge for determining teaching and other classroom actions. However, I would argue that general beliefs of teachers, which are outside the scope of educational beliefs, also have the ability to impact their judgement and decisions. This is particularly true for teaching SSIs, as it includes dealing with controversial topics, and discussing moral and ethical dilemmas, wherein the beliefs reflected are more generic and are not just restricted to educational beliefs. Hence, this section will discuss the teachers' narratives through which influence of teachers' beliefs on the SSIs teaching is reflective from a broader perspective. The teachers' beliefs discussed in this section include their beliefs about students, teaching methods, and the purpose of education. This section further touches upon the link between teachers' beliefs and their personal biography, teachers' beliefs and their perspective, and the interaction of teachers' beliefs and their classroom actions.

6.2.1. Teachers' Beliefs and their Personal Biography

The personal biography of teachers, i.e., their background and past experiences, has a significant impact on the formulation of their beliefs (Goodson, 2003). As mentioned above, the beliefs are linked to the personal, episodic and emotional experiences of teachers, which are the key constituents of one's personal biography. In case of Andy (a high-school teacher at Modern High School), a significant level of association was seen between his personal biography, i.e., his treatment as a student, his financial conditions during his childhood, etc. and the

formation of his beliefs. He belonged to a working class family and started supporting his father financially at the age of 13. At several occasions in his interviews he recounted the instances from his childhood - the way he used to respect his parents and teachers, understood the value of money from early on, and the importance of having a clean environment. During his interviews, he inadvertently resorted to comparing his episodic memories (that reflected his beliefs) to the behaviour of current students, and expressed disappointment at the current situation.

> *"I used to come back home from school at 2:30, after that I used to go to my dad's shop and used to come back at 10'o clock at night with my father. But now this generation is not responsible (...) they just know that what their rights are but they don't know what their responsibilities are. (...) there are no etiquettes or manners or values or responsibilities. (...) they are not even able to understand what we people want to tell them [teach them]. They are not going to be convinced if they don't want to be [speaking in context of students' awareness related to the teaching of environmental SSIs]." [Andy-I1-R8]*

He explained that in past he did try and make students understand what he believed to be the right morals and values. However, a lack of what he perceived to be appropriate responses from students, and the disparity between his beliefs and the current situation led him to cease in any attempt or activities, particularly the ones targeted at understanding values related to SSIs. Andy's decision to cease the discussions on moral or ethics of SSIs in his classrooms were also influenced by how he was treated as a student in his school days. He recollected in his interviews that he was taught in a much disciplined (non-interactive) environment and he believed that students were able to learn much better in that way. Hence, partly due to all these he chose the explanatory lecture method (discussed in previous chapter) as his way of teaching SSIs to students.

Another example of the role of personal biography in formation of beliefs is of Katie's. She narrated an episodic memory of the time when she was pregnant, while she was hospitalised she witnessed another case of another pregnant woman had rubella. This lady was advised by the doctors to abort the baby, as doctors felt that the baby would struggle to lead a normal life. However, the woman decided to

keep the baby. Katie said that, this incident had a major influence on her beliefs. According to Katie, it was a logical and the right decision to abort the foetus based on the scientific evidence. However, that woman decided to keep the child despite knowing that her baby would be disabled for the entire lifetime. *"The doctor was showing it to her in an ultrasound scan, the backbone was not proper, the nerve cord was not proper. But still she was not convinced so what is the idea of giving birth to such a child and making him suffer throughout, and the mother and father both will also suffer to see their child live a crippled or abnormal life." [Katie-I3-R10]*. After this incidence, Katie was determined to make her students more scientifically literate, as she felt that people should be ready to make "logical and sensible decisions" based on scientific evidence and not only their emotions or personal feelings, when faced with any such situations.

> *"In my thinking its better not to have such a life, it is a sensible decision to opt for abortion than to give an abnormal life to someone. But if they do come in world, then it is our moral responsibility to take care of the baby. The point is that people go with their emotional instincts and not make logical or sensible decisions. After this [incident] like I said I always try and set aside a period for discussion with students over these topics. Now they [students] do understand science, so if the time comes they are prepared to make the right decision [about any SSI]." [Katie-I3-R10]*

6.2.2. Teachers' Beliefs about Students

Teachers' beliefs about students have been studied in previous research (Ekborg et al., 2010, Lee et al., 2006), and are considered as an integral part of teachers' belief system. According to Wallace and Kang (2004), teachers' beliefs about the perceived limitations of the students in terms of their ''ability'' and ''maturity'' can influence their classroom teaching. Two different forms of influence were witnessed in my study over such beliefs of teachers about students. First, the teacher (Andy) did not conduct any interactive activities with students over his beliefs about students, and second teachers came up with novel ideas to teach SSIs so that "young and immature" students can be sensitised towards SSIs. These two forms have been discussed below.

Andy's beliefs about the students and in particular about the limitations of the students shaped his decisions and classroom actions. To provide the context, the school Andy was teaching at, had students primarily from affluent families. Andy, as discussed previously, belonged to a working class family and supported his father in his work as a teenager to manage finances. Andy repeatedly compared his situation to that of students, and believed that the current students did not have any "good values", i.e., they did not respect their parents and did not value money in the same way he did. Consequently, he (as also discussed previously in his biography) after trying a few times to convey what he termed as "good values" to the students, stopped any activities that related to conveying moral, ethics, or values. Instead, he focused completely on imparting scientific canonical facts to the students.

> *"They (students) don't understand that whether they live in a mansion or a two-bedroom house, they are going to breathe the same air, live in the same environment, and eat the same pesticide ridden crops and vegetable. (...) they are not socially responsible because the most common excuse is what difference it makes, if only one out of the million is doing it [being socially responsible or taking care of the environment]." [Andy-I1-R9]*

> *"There are two boys (...) I told them that you two are coming (to school) from nearby places, why are you coming separately. Why don't you come together? They answered sir, what difference it makes. Why should I wait for him? (...) When I told them two vehicles means double usage of petrol, double pollution, and double harmful gases emission. If your one act can reduce it, then why don't you do it? Then the answer is who is that much bothered. There is one boy who comes in a two – seater car. One who comes on an S-class Mercedes (...) they don't bother about all these things. For them, only lavish life-style matters, not values." [Andy-I1-R10].*

This shows his strong beliefs about the students apparently not valuing the environment or about anything/anyone other than themselves. These beliefs drove his judgement and teaching actions. He chose explanatory lecture method to teach his students and just focused on ensuring good marks as he believed that students aren't capable of understanding any ethical or moral values. *"In parent teaching meetings, parents come and tell me how their children behave at home. (...) If they cannot even*

respect their own parents, how can I expect them to do anything for society?" [Andy-I2-R6].

Hence, he felt the teaching of any aspect of SSIs to these students, other than canonical facts important from exam perspective, was a *"waste of time and energy"*, and there was no need for that. He further mentioned that: *"There are many serious discussions and debates happening on these kinds of topics on the news channel and in media. So why should we involve our students so much in this, we don't have this much time (...), I can but the problem is that will just waste our time and you get nothing out of it." [Andy-I1-R39].* The idea of he would "get nothing out of it" as discussed by him in other parts of his interviews is twofold, i.e., a) SSIs activities are not interesting (to him) as they do not cover canonical facts and are not meant for securing good grades, and b) students, as per his belief, wouldn't grasp the importance of it. Such beliefs concur with the findings of Cronin-Jones (1991), where she discerned the strong beliefs of teachers about students that, students need explicit direction and learned best with "drill and practice" (similar to Andy's teaching method – see previous chapter), and a focus needs to be on the factual content acquisition.

Other examples of the teachers' beliefs about students and their influence on SSIs teaching are that of Sofia and Jane. As discussed in previous chapter, both these teachers considered their students to be young and not mature enough to form strong arguments for activities like debates. This did impact their teaching method and approach. Sofia, while conducted debates on SSIs, moulded the debate topic in a way that the situation would not require students to form strong arguments and they would still understand different aspects of the topic. Jane, on the other hand, taught with a novel method of conducting debates with these young students. She first conducted a discussion with the students on SSIs and facilitated students with facts and different aspects to help them build their arguments, and later turned the discussion into a debate. These examples have been discussed in more detail in the previous chapter. These show a variation in different teachers' actions for SSIs, when the underlying beliefs about students are similar.

6.2.3. Teachers' Beliefs about the Purpose of Education

Another important facet of teachers' belief systems is that of their beliefs about the purpose of education. Victoria, from Rockford School, completed her education in the field of environment, and was appointed as the environmental manager at Rockford school. She believed that it was her moral responsibility to protect the environment. Her personal beliefs also drove her educational beliefs where she felt equally responsible for making the students aware about SSIs and bringing about a change in their outlook towards SSIs, especially environment related SSIs. This reflects her beliefs about the purpose of education is to bring about an awareness in students that ethics and values exist in science, which is required to make decisions about certain issues. Her beliefs infused a sense of passion for being involved in and teaching the environmental-related SSIs to students. The state of her passion can be inferred from her avid commitment towards the teaching and learning about such issues. She was an active member of many different communities that work towards different environment-related causes, such as, the Ocean Pollution Community (work towards oil-related pollution in oceans). She regularly travelled all around the country to participate in the events and activities for such communities. She had a considerable social presence in the environment-related communities and used her status to get her students involved in state and national-level activities for environment-related SSIs. The formulation of Sofia's beliefs can also be accredited to her biography. Her educational background, job experience, and constant involvement in environment related activities are linked to the beliefs and her commitment towards these issues.

Katie believed in a similar responsibility, like Victoria, towards sensitising the students to SSIs. However, she did not just focus on sensitising the students towards environment-related SSIs; she believed in a general social responsibility of herself and students. This general belief of Katie had an impact on her educational beliefs, as she employed teaching methods to make her students scientifically literate. She wanted her students to develop rational thinking to be able to responsibly analyse any situation with a rational mind even beyond their school life. She conceptualised her teaching tasks according to her educational beliefs so that she could bring an attitudinal change in students towards SSIs. Her focus, similar to Victoria's, was making them retain the important messages of discussions and

activities and developing a feeling of "we have to do something". While Victoria primarily focused on environmental issues, the focus of Katie was on other SSIs as well. As witnessed from Katie's and other teachers' interviews, general beliefs of teachers are important to be considered for an impact on the teaching of SSIs, along with the educational beliefs of teachers.

> *"They learn it, understand the logic, sometimes discuss it, write it and forget it. This kind of teaching does not give them a sense of responsibility or say, like the feeling that 'yes' this is our world, we have to do something. I have myself seen that if we teach them this in class they don't give an extra effort. They have so many other subjects to do, curricular and co-curricular activities, why would they be bothered. Here it is the teacher's moral duty to make them realise that this is something crucial and I tell you students at this age are full with energy, if you show them the direction, they are like so passionate that they will find the way themselves. You just need to be there and make them realise what is their role." [Katie-I1-R13]*

Pam, a science teacher from Springdale school, also showed beliefs similar to Victoria's and Katie's. In her interviews, she showed strong beliefs about her responsibility as a teacher to sensitise her students towards the importance of SSIs and the different aspects of it. However, some similarities and contrasts were witnessed in her actions from that of Victoria's and Katie's. Pam while conducting activities related to SSIs, expected students to understand her views and share her views as a take-home message. She had the conception of a "right" message or an outcome from each discussion and worked intensely towards making students realise that "right" message during activities. If failing to do so, she considered the activities as unsuccessful and waste of time. This was also the case for Katie, as she believed in students understanding the "right" message about aborting a foetus due to mother having rubella. For Katie, the notion of right message was that SSIs should be resolved by scientific facts and not by emotional considerations. This relates to the findings of Roehler et al. (1988) on discourse about beliefs in comparison to knowledge, that "beliefs are surrounded by an emotional aura that dictates rightness and wrongness". Pam's emotional connection to that "right" message impacted her teaching and channelled her efforts during teaching-learning activities, related to SSIs.

"Usually, I am able to convey my message to the students which makes me feel very delighted and successful, (. . . .) But sometimes there are bad days, which go in a way which I don't want. (...) that's not for what I came to class for. So I felt time was wasted, I could've used for completing the syllabus. And somehow it came to a conclusion [other than what I intended]. Then I felt frustrated that what kind of message I have passed on. (....) For me it wasn't successful (...)" [Pam-I2-R28-29]

6.2.4. Teachers' Beliefs and Actions

A bi-directional influence between beliefs and actions can be construed from the previously discussed examples in this section. Teachers' beliefs guide their actions and make sense in relation to each other (Bybee, 1995, Clark and Peterson, 1986, Pajares, 1992). Scott et al. (1994) also described a bi-directional relationship between beliefs and actions, where actions are influenced by one's beliefs, and beliefs are formed from the influence of one's actions. In cases of Andy and Victoria, they showed very strong individual beliefs, which they realised in actions during teaching. Both Andy's and Victoria's actions have shown links to their beliefs and they both showed passion for their respective beliefs with their targeted actions in line with their beliefs (Andy in teaching for securing marks and teaching canonical facts, and Victoria for involving students in activities targeted at sensitising the students towards SSIs). On the other hand, from their responses, their beliefs were strengthened overtime with their actions and the achievement of the desired results (grades for Andy, sensitising of students over time). It can also be inferred from here that when teachers have strong beliefs about something, then they put in additional efforts to realise those beliefs in action.

Roehler et al. (1988) discussed another aspect of teachers' beliefs where they asserted that the beliefs *"are static and represent eternal truths that remain unchanged in a teachers' mind regardless of the situation"* (p. 164). Similar experiences have been witnessed in this study. They were most explicit in the case of Andy. For instance there was a change in assessment system in Indian CBSE board schools, which (based on the teachers' interviews) was welcomed by a majority of teachers in this study. However, this change contradicted Andy's beliefs and he

mentioned several times that the new changes were bad for students and led to failure. For example, he firmly believed in teaching by lecture method, but according to the new changes teacher had to conduct certain interactive activities for the teaching of SSIs. He believed that any interactive activities for SSIs or any other topic would only create indiscipline in the classroom and students wouldn't gain anything from it. Even the activities that were made obligatory, he felt were a waste of time. He maintained that the older system that matched to his beliefs was much better than the new system.

> *"The problem is only in the system; if you compare it against previous system this is the worst system. If it continues like this for coming years, it will be a big problem because we've seen in past 5 years that level of students (in terms of grades) what used to be 5 years then is not there anymore." [Andy-I3-R18]*

6.2.5. Teachers' Beliefs and Teachers' Perspective

During the course of this study and the analysis regarding teachers' beliefs some interesting instances were encountered regarding the relationship of teachers' beliefs and their perspective. As discussed in Section 2.1, teachers' perspectives are often misconstrued by researchers and practitioners as being the teachers' beliefs. However, teacher's perspective is a broader term defined as "*a reflective, socially defined interpretation of experience that serves as a basis for subsequent action (…) a combination of beliefs, intentions, interpretations, and behaviour that interact continually*" (Clark and Peterson, 1986) (p. 287). The stated relation suggests that perspectives subsume a set of equivalent variables, i.e., beliefs, intentions, interpretations and behaviour. However, based on the analysis in this study, beliefs have been clearly found to be much more significant than the other variables. The beliefs, intentions, interpretations, and behaviour instead of being completely equivalent as inferred from the definition, are significantly impacted by beliefs. For example, Andy's beliefs dictated his intentions to teach, his interpretation of the reaction of students, and behaviour towards the class or students. This in whole formed his perspective towards teaching of SSIs to students, with a major contribution from his beliefs.

Brown and Cooney (1982) explained another form of relation between beliefs, actions and behaviour. They stated that the beliefs are dispositions to action

and major determinants of behaviour. In Jasmine's case, her beliefs were linked to her professional background as a researcher. At first, she wasn't really keen on the job as a teacher but took it due to convenience. Her beliefs formulated her perspective towards teaching and the way of teaching, as she did not confine herself to simple classroom teaching. She believed in research methods, and employed those methods in her teaching. This also drove her attitude and expectations from students as she felt that students should be scientific literate and should be able to think rationally even if they decided not to study science in secondaryeducation.

6.3. Teachers' Identity

Gee (2000) classified teachers' identity into multiple perspectives based on teachers' nature, working environments, personality traits developed over time and their affinities. In the context of this study, the 'institutional identity' – the identity perspective related to the working environment is of particular interest. According to Gee, this perspective on identities can be determined by the position assigned to a teacher by his/her institution. The authority, rights and responsibilities assigned to this position are what define the institutional identity perspective. Goodson (2003) characterised identity as an "ongoing process" which is constantly evolving by the consequences of *"interaction between the personal experiences of teachers and the social, cultural, and institutional environment in which they function on a daily basis"* (Sleegers and Kelchtermans, 1999) (p. 579). The personal experiences, as discussed in the previous section, are the foundation of teachers' beliefs. Where teachers' beliefs are central to the experiences packaged in one's mind, the identities of teachers refers to the social interaction of teachers, which are built upon beliefs. In context of an institution, identities are further characterised by a set of authorities that define the position of that identity. For example, at an abstract level if a person is "science teacher" then there are a defined set of authorities that can be linked to this identity. However, it is very difficult to keep the personal aspects separate from it, and the interaction between the beliefs of teachers and their identity is discussed further.

Beijaard et al. (2004) express professional identity as an amalgamation of personal choices and context. Teachers, when put in a similar context are expected to behave in a similar fashion, but the difference is in the way, for example, the way teachers perceive the expectations of school authorities from them because of their personal choices and the amount of significance they attach to different things. Feiman-Nemser and Floden (1984) mention that teachers at the same school, within similar context, tend to develop their own teaching culture. Hence, teachers' identity, in particular their personal choices and the values they attach to certain topics, impacts their teaching of SSIs, even when they are working under similar environment. This was also evident in the context of Modern High school, where Daisy and Andy, were subject to similar expectations and being at the similar position as a science teacher had similar institutional identities, but still differed in their approach to teaching SSIs due to the different values and beliefs they attached to it. Andy used lecture method because his focus was on securing grades for the students, in contrast to Daisy who felt responsibility towards developing rational thinking in students and used interactive methods for teaching SSIs. This also shows the interaction between different factors, i.e., teachers' beliefs and teachers' identity that guide teachers' actions. Drawing upon the above findings, it is clear that a teacher's identity is influenced by her current choices and values. Extending this thought, Day et al. (2006) in their findings suggested that a teacher's identity is not only defined by their current and previous identities which are influenced by their past episodes and personal histories but *"through their beliefs and values about the kind of teacher they hope to be in the inevitably changing political, social, institutional and personal circumstances"* (Day et al., 2006) (p. 610).

The above statement also echoes that identity is a dynamic and emergent concept. Its distinctiveness is in thinking about a teacher not just as an individual but as someone who works at a place (school), interacts with the people and acts in a way that are influenced by the people in that institution. James-Wilson (2001) (p. 29) concluded that a teacher's identity is affected by *"how they feel about themselves"* and *"how they feel about their students"*. This further helps the teachers to fathom the valuable adjustments in terms of their teaching and their beliefs about the same.

Ryder and Banner (2013) (p. 500) captured the definition of teachers' identity as the notion of *"who they saw themselves as being"*. A number of variations have been witnessed in terms of what teachers identified as. There are teachers who identified themselves, or had identified themselves at some point in their past as a 'researcher' (Jasmine), 'statistician' (Sofia) and 'environmentalist' (Victoria). The other forms of identities are discussed further in the next section. Further in this section, the change in identities of teachers, the tension within their identities and the identity specifically in the case of new teachers has been discussed.

6.3.1. Changing Identities

Coldron and Smith (1999) characterised teachers' identity as not a "stable entity", which is subject to change any moment, owing to teachers' 'biographical projects' or their working environment (MacLure, 1993). MacLure (1993) proposed the term 'biographical project' as an interconnected nexus of personal concerns, values, and aspirations that influence the teachers' judgement and decisions. This can be exemplified by experiences of Sofia, a teacher in this study who has a Master's degree in environmental studies and worked for the state pollution board for three years. She had a special inclination towards teaching of environment-related SSIs due to her close encounters with the pollution related issues in her previous job. This inclination was an important element of her identity, and infused in her a sense of passion for working towards environment-related SSIs. However, when she moved jobs from the pollution board to being a teacher, her professional identity was redefined. According to Sofia, she inadvertently grew past her identity as a 'statistician' at pollution board, to being a 'teacher' that was focused on sharing her assimilated experiences in the form of stories with the students. However, this change in professional identity was still anchored to her personal concerns towards environmental-related issues. For Sofia, her strong belief in highlighting the issues of pollution and global warming remains firm but her identity had shifted from being a 'statistician' to a 'teacher'. The change in Sofia's working surroundings and the expectations from her as a professional led to the change in her professional identity. This aspect of change in her professional identity is consistent to the findings of Reynolds (1996), where he emphasised the profound impact of teachers' surroundings, expectations from them and what other things teachers allow to impact them on their professional identity.

Similar experiences were shared by Jasmine, who mentioned that how at one point she considered teaching as an inappropriate profession for her, as she always wanted to be a researcher. Before beginning teaching profession she worked as a 'researcher' in a laboratory. However, due to personal reasons she joined teaching profession, but seemed unsatisfied with it, which she later owed to her working environment in her previous school and later, when she changed schools, she saw a considerable change in her identity. Drawing upon the same findings and Jasmine's views in her interviews, it can be inferred that the school's culture plays a very important role in shaping a teacher's professional identity. This was also echoed by Mockler (2011) (p.131) where she stated that, "*The culture and nuance of particular schools in which participants had worked (especially over extended or particularly significant periods of time) emerged as highly significant in shaping teachers' professional self-image.…".*

In Jasmine's case, the previous schools that she had worked in impacted her identity negatively, where she started doubting herself as a teacher. However, a change in the professional environment reinstated her belief in her identity as a teacher. *"I never wanted to be a teacher. I wanted to go to abroad to do research (…). So the researcher in me was always there but never got an opportunity to explore that side (in school). (…) I think I am a mixture of researcher and teacher." [Jasmine-I1-R12].* This is in coherence with what Mockler (2011) concluded further in her paper that wider prospects of growth and development provided to a teacher in a professional environment influence a teacher's identity. She also stated that access to this kind of opportunities is directly related to the leadership and culture of the school. This change in the Jasmine's identity, deemed positive by her, is also linked to the leadership of the school, which is discussed in more detail in the 'Leadership' section further in this chapter.

> *"See, I have a research background (...) that researcher in me is still alive and active and that gives me that zeal to do all this." [Jasmine-I1-R7]*

Jasmine's identity as a researcher influenced her selection of teaching methods, and activities. She wanted her students to build clear concepts about the scientific issues in their minds and develop the inquisitiveness of a researcher. The

teaching methods used by her were primarily research-based e.g., conducting plant cloning in school laboratory, initiating the Bio-Diesel project, etc. The most remarkable aspect of her development as a teacher-researcher identity was the support she got from the school leader and the school culture. While comparing her identity as a teacher from what she was in previous schools, she added that she has become a 'better' teacher and feels more satisfied and 'motivated' as a teacher. This is in coherence with the findings of Nais (1989) that teachers feel more secure in their job *"when they have a good relationship with pupils and when they function well in the school organisation"* (p. 292).

6.3.2. Subject-specific Teacher Identity Tensions

Gee (2000) mentioned that the institutional identity of a teacher depends upon whether the position is imposed on a teacher or is considered as a vocation. For example, in Rockford school, Victoria was assigned as environmental manager in the school and was assigned this position to ensure the school does well amongst the list of Green Schools in India. She was given the authority to decide upon the activities for the teaching of environment-related SSIs and change the practices if she felt so. She felt her position as a vocation and took special initiatives for teaching of SSIs at Rockford; for example, she regularly conducted activities targeted at learning about environment-related SSIs in what she believed to be a "fun" way for students.

However, if the institutional identity is imposed on a teacher that can lead to tensions within teachers between what they believe themselves to be and what is imposed on them. At the same school as Victoria's, Jane did not relate to all the extra activities as a science teacher. In her interviews, she mentioned that these activities were imposed upon her, as she wouldn't have carried out these activities on her own. She at times felt like an "art teacher" rather than a science teacher. This conflict between what Jane wanted to do and what she was expected to do constrained her identity as a teacher. The activities have been discussed in detail in the previous chapter. Jane's conflicted identity made her feel alienated from the values of the school. She being a science teacher in a Green School never felt the zeal to participate in the activities that other senior teachers prescribed.

"See when I joined this school; I felt that I couldn't match their speed of working. We are given deadlines for so many extra things. Then I only have my zero or extra period to complete these works like completing data, etc. We are expected to have house [special clubs in school] duties; I need to prepare students for morning assembly speeches [related to SSIs]. I've to guide students to all these extra useless things. I have to prepare my class too for dance, music, speeches, and thought for the day for the morning assembly. Every month we're given some extra duties like decorating boards [related to SSIs]." [Jane-I2-R4]

Her conflict was evident in other instances from her interviews where she hinted towards "leaving her job" or "changing the school" but felt captive in the current job because of her dire "financial constraints". These findings are mirrored in Beijaard (1995), MacLure (1993) research who concluded that if the teachers feel detached from the values and practices of their schools, then there comes a stage where they can no longer identify themselves with their jobs and tend to experience thoughts of resigning, stress-related illness or early retirement.

Simi witnessed similar tension at Blue Bells School, where they organised a special public event related to awareness for environment related SSIs. In this event, students wore green clothes and held posters, banners, and placards with slogans related to environmental SSIs. Students prepared for this event, weeks before the event. There were other activities involved in this event were poster making and two street plays on the topics "Stop Pollution Save Earth" and "Join the Revolution, Stop the Pollution". Simi, in her interviews, reflected on this more as an obligation. According to her, such events do not create any long lasting learning opportunities for students. She felt the tension as again she felt that school authorities imposed the identity of an "art teacher" upon her, and felt the tension, as she couldn't relate to it.

"These types of events (SSIs related public events) are meant to create awareness, but it is hectic for us too. I am not an art teacher, and neither am I good at it, still I have to do all this. See the event is for one day but the preparations start way before. (...) I don't have whole year to spend on all this. I have to finish my syllabus too." [Simi-I1-R5]

Ryder and Banner (2013) (p. 501) also witnessed similar tensions in teachers' identities where a teacher reportedly felt like "a bit of *Personal and Social Education Teacher*". This teacher could not relate to the discussions held in the classroom and reported frustration as the discussion did not allow him to focus on canonical science. In my study, Andy also expressed similar tensions when he was asked by school authorities, or commanded by the needs of curriculum to organise certain activities for SSIs awareness in students. He saw these as a threat to his identity, as at one point he mentioned that it is not his task to conduct such activities, as he is a science teacher not a "moral science teacher". The examples in this section show a highlighted one of the distinctive findings of this study.

6.3.3. Teachers' Identity who are new to School

Reynolds (1996) expressed another aspect related to teachers' identity where she described that the teachers new to a school have a primary goal of blending into the school and establishing themselves as "good teachers" according to the prescribed norms of the school. In this study, we found similar accounts from relatively new teachers in the schools that accounted similar experiences and were keen to be "enculturated" as good rather than asserting their own identity into teaching or standing out with their unique teaching methods. For example, Kady in Bluebells School mentioned that she only works towards the normal goals set for the teachers by the school authorities and does not try and change much even if she feels differently. This showcases a conflicting interaction between the influencing factors: teachers' identity, teachers' beliefs and their teaching goals.

> *"Sometimes I personally do not agree with the teaching methods or discussions we have with our senior teachers. But I refrain from telling them what I feel. I feel may be they are more experienced and know better about things than me. Even if I know I am right, somehow I just accept their ideas. You see, I came here only last year in April and they have been here since the [start]." [Kady-I1-R17]*

This also highlights that her identity was suppressed in the process where she felt that she was expected to follow what her senior teachers suggested. This is congruent with the thoughts of Cooper and Olson (1996, p.87) that when a teacher is

asked to fit in a prescribed role to which it is difficult for the teacher to related, she suppresses her personal voice in favour of an objective and distanced voice. Similar views were shared by Dolly also, who, although had been teaching in Queen's High School for four years, still considered herself relatively new and inexperienced in comparison to her principal.

> *"We have to follow what Mam [the Principal] suggests, (...) sometimes it is like we are not willing to do it, but slowly you realise that you have to do it (...) it is our job to do what she says. And I think it is beneficial for our school's reputation too." [Dolly-I1-R4]*

6.4. School Leadership

The previous two factors dealt with the personal side of the teachers, i.e., their experiences, and the interaction between the experiences. This section provides insight into an institutional level factor, i.e., the school leadership that impacts the teaching of SSIs. The school leadership refers to the school principal, head teachers and subject leaders in the school. In this study, school leadership was found to be one of the key-influencing factors impacting the teaching of SSIs. Although the existing research on school leadership do not agree on a single definition, but most descriptions of school leadership agree on some fundamental characteristics and functions of it. These fundamental functions are about exercising influence over others and providing direction to achieve school's vision and goals (Leithwood and Riehl, 2003). Leadership is often considered as a role vested in a single person at the top of the hierarchy, but contrastingly is more of a function dispersed among a number of people in the school (Mulford, 2003). The dispersion of the authority to exert influence is over the entire hierarchy of the school leadership. Such dispersion of authority across hierarchy (throughout school) was witnessed in four out of five schools in this study. The hierarchy structure in the schools covered in this study has been previously discussed in the background section.

At the analysis stage in this study, certain key characteristics associated to the school leadership were witnessed. However, on a closer look they showed a pattern highlighting the similarities and the dissimilarities between the different leadership in different schools. Although the levels of hierarchy were similar across

the schools (see Figure 4.1), the level of authority to make decisions was not the same for each role. For example, in some schools the subject teachers were not involved in the decisions made regarding the curriculum. While in some other schools the teachers had the authority to choose their teaching methods and make any deviations from the prescribed curriculum (although minor). The five schools in my study could be classified in three clusters based on the characteristics of the distribution of decision-making authority at the different levels of authority. Blue Bells, Modern High, and Rockford Schools were in one cluster for this property. Taking into consideration the different properties, such as communication between teachers and leaders, involvement of teachers, etc. two more clusters of schools were created. A significant level of overlap was witnessed between the clusters pertaining to different properties or characteristics. Based on these characteristics, a single term was coined for each style of leadership delineated from these properties. Table 6.2 explains these three styles of leadership, i.e., Monocratic, Oligarchic, and Democratic styles of leadership, based on the outcomes of this study. This section reflects on the findings where various aspects of school leadership influenced the teaching of SSIs in the study. These aspects include, among others the style of leadership, the level of motivation from leadership, resource allocation by leadership.

6.4.1. Styles of Leadership

The results from this study revealed a spectrum of leadership styles, described further, across five schools. The different leadership styles are based on the distribution of authority in the schools. There were distinct characteristics of leadership styles that reflected in the data. These characteristics were generalised into three leadership styles and were labelled as monocratic, oligarchic, and democratic. Table 6.2 shows the details about these leadership styles. These styles are further described with examples.

Table 6.2. Styles of Leadership

Leadership Style	Description	Schools
Monocratic	A single leader gives the directives to all the subject teachers, and the teachers are expected to follow them. There is not much consultation from the subject teachers and all the key decisions lie with this single leader.	Queen's High school
Oligarchic	All the key decisions regarding schools' overall goals and specific teaching related goals are discussed and agreed upon amongst a chosen set of leaders in the school.	Blue Bells, Modern High, and Rockford schools
Democratic	An inclusive style where the key decisions are taken by consulting with all the involved personnel, including the subject teachers.	Springdale school

6.4.1.1. Monocratic Style

The monocratic style of leadership was witnessed in Queen's High School in this study, where the principal was the single leader making unilateral decisions. The principal being one of the school founders assumed personal responsibility towards maintaining the local identity of the school as a 'Green school' (which was an integral part of school ethos). She controlled the planning and execution of all the environment-related activities and also integrated them with the science curriculum. Teachers were expected to follow those directives irrespective of any reservations about the decisions. This unilateral communication led to teachers feeling no sense of ownership in their teaching, and being constantly overburdened by the unreasonable expectations of the principal. During her interview, Dolly revealed that the principal of the school usually decides activities related to environment-related SSIs. She said that if the principal suggests that they need to organise a declamation contest (declamation contests are fairly common in Indian schools where students present a speech on a given topic) on global warming then they have to do it. She admitted that she might not personally agree with some of these activities or the teaching methods prescribed by the principal for teaching in the classroom, but she acquiesces to whatever her principal "orders" the teachers to do. Queen's High school was a relatively small school in comparison to other schools covered in this study. Hence, it was relatively easy for the principal to follow a monocratic leadership style,

where she managed all the activities of the school on her own without dispersing any authority to others. It is a very special arrangement, which might not be possible in other schools with a greater number of students and staff. It can be presumed that this kind of leadership does not give the teachers the scope to explore new methods of teaching on their own. They are just expected to follow the prescribed methods.

6.4.1.2. Oligarchic Style

The second leadership style, i.e., oligarchic style school leadership was witnessed in three schools. Blue Bells, Modern High and Rockford schools followed this style of leadership. In the context of SSIs teaching, school leadership involving a principal, head teacher and the subject heads took the key decisions. Subject teachers were seldom a part of this process. The SSIs-teaching related activities and teaching methods were decided in meetings at the start of an academic year and were conveyed to the teachers. The subject teachers' freedom to customise the plan designated by leaders was subject to the immediate leaders, i.e., subject heads or head teachers. Similar to the monocratic style, the sense of inclusion and ownership was also missing in the subject teachers that were not part of the decision making process and received the directives from the leaders higher up the hierarchy.

Rockford school, similar to Queens High, aimed at maintaining the status of being a 'Green School'. Both of the schools had a good reputation in their respective cities. Both the schools thrived to maintain that reputation and hence the leaders played a pivotal role in setting the path for their respective goals. The school leaders at Rockford school ensured that the teaching-learning activities in the entire school for science, geography, and language classes are cantered around this aim. This consortium of decision-making leaders at Rockford also included Victoria, who although wasn't placed at a higher role in hierarchy her inputs were still considered valuable for the decision making process due to her experience and background in environment related topics. Victoria and Katie (subject head) were both part of this process, and felt a sense of ownership towards this. The other science subject teachers perceived the activities designated by the school leaders as being imposed on them. It was interesting to note that some teachers happily accepted this goal of working towards maintaining the local reputation of the school and worked along as well.

These teachers were involved in the decision making process of the schools and were responsible for the academic plan. However, a few science teachers did not agree with the decisions and found the goals set for them as irrelevant. The activities assigned to them concerning Green School vision, included, amongst others, chart and model preparation (described in the previous chapter), decoration on a display board, and banner painting. Jane, for instance, saw herself more as an art and craft teacher when doing these activities, rather than a science teacher. This affected their (teachers that did not agree with the decisions of school authorities) teaching of SSIs as they felt over burdened by these extra tasks, and did not feel any ownership that at times led to a teaching environment lacking in stimulation. This has been described previously under subject-specific teacher identity tensions in teacher identity.

The schools that were not 'Green schools' or had explicit aims defined towards environmental issues, i.e. Modern High and Blue Bells, had oligarchic leadership style. The leadership style had a direct influence on the teaching of SSIs. In Modern High school, the structures of hierarchy were split in various divisions of the school and were appointed with a head teacher. For example, students who were 4-5 years were included in Kindergarten division, (6-10 years) old in Primary division, (11-13 years old) in Middle division and (14-17 years old) in Secondary division. At Secondary level, they followed an oligarchic style with principal and the head teacher. At the division level, the styles were further varying depending on the head teacher. For instance, in the middle division at Modern High, they followed a democratic approach where all the science teachers were duly consulted for all the teaching-related activities. Teachers expressed in the interviews that they felt ease in communicating their ideas and reservations in this setting and expressed the positive influence it had on their teaching. Contrastingly, in higher division the headmistress followed oligarchy where only subject heads were involved. The impact of this setting can be inferred from an incident when science teachers assigned an SSI activity to all the students, however the school leaders upon complaints from the parents; cancelled this activity without consulting with the teachers. Teachers felt a lack of trust in them from the leaders and when interviewed showed a general consensus of not conducting many SSI-related activities after this incident.

6.4.1.3. Democratic Style

The third leadership style, i.e., democratic style, also termed as distributive leadership (Spillane, 2012) refers to inclusive decision-making where all the teachers that would be directly impacted by teaching-related decisions were part of the process. For example, the director at Springdale believed in reaching a consensus with all the concerned teachers for designating the path for maintaining the vision of their school as a Green school. This democratic approach from school leadership made many subject teachers, as claimed by teachers interviewed, feel empowered in the decision-making process, and teachers were frequently assured about the 'pivotal role' they play in any of the school's endeavours. This brought a sense of ownership and initiative in the teachers. Jasmine organised many SSIs-related activities on her own and never considered the school's goal of being on the Green schools list as an overburden to herteaching.

"What our school says is, in this institution teachers, students and the parents are the stakeholders and we need to keep all of them happy. So that means that we as teachers are a part of that theory [notion of considering as an imperative part of the institution]. In rest of the schools, especially in the one I was before, the teachers have to make the students, parents and the higher authorities' people happy. This is the main difference between this school and other school." [Jasmine-I3-R26]

6.4.2. Leadership authority

The leadership styles, discussed earlier, were different from each other in many ways. The different ways in which leaders exercised their authority featured strongly in the interviews. Since, there were three different styles of leadership, the way and the extent in which these leaders exhibited their authority was also varied. For example in monocratic leadership style, the principal was responsible to take all the key decisions regarding the teaching, administration and discipline of the school. Here in this section, I will concentrate on those types of authority, which featured in teachers' interviews and affect the teaching of SSIs. For this purpose, I selected Tirri and Puolimatka's (2000) classification of types of authority, namely epistemic and deontic. Deontic authority concerns the authority of a person to pass the orders i.e. s/he is in a position to propose, decide and announce the orders. Epistemic authority concerns the authority of a person over a subject's knowledge i.e. s/he is

having appropriate knowledge of the field in question. In the context of this study, a fair share of authority lay in the hands of the leaders. The most distinctive finding was that the way the leaders exercised epistemic and deontic authority or a combination of both had a varied impact on the teachers teaching of SSIs. This will be described further with examples.

For instance Victoria had epistemic authority over teaching of environment related SSIs i.e., she as a part of the set of leaders had appropriate knowledge to take decisions for teaching SSIs. She along with Katie, were a part of the team of leaders in Rockford School who had epistemic authority to decide over the lesson plan of teaching, activities, methods etc. The decisions of the leaders that possessed both deontic and epistemic authority were rarely challenged in this study. For instance, the principal at Queens High school had deontic authority from her position and epistemic authority from her experience in teaching environment related issues. Teachers, even if they did not agree with the principal's decisions initially, respectfully consented to her stance due to her authority in both terms (as already discussed in teacher's identity in Section 6.3.3.). On the other hand in monocratic or oligarchic systems, the decisions by the leaders possessing deontic authority but lacking epistemic authority received only grudging acceptance from the teachers. In certain instances, this grudging acceptance came out in the form of resentment and even impacted the emotional well-being of the teachers. For example, Jane narrated an incident where she felt belittled by a school leader's comments about her subject and considered that as 'mockery' of her subject. Consequently, the enthusiasm of the teachers is impacted by such incidences that can further lead to unintended consequences on the teaching.

> *"Then nobody is ready to teach biology in class, then principal calls me and says why is no one ready to teach biology, what's in there just food goes here and here it comes out. She's making fun of somebody's subject. You're making mockery of the whole system. That's why the system is not working. (…) They don't care what does our lesson expects, they just see what school authority [referring to Science subject head and her headmistress] is saying but not what's good for children."[Jane-I1-R7]*

Another such incident was witnessed in Modern High school where a school leader cancelled an activity (not linked to SSIs) without trying to understand the rationale behind the introduction of this activity. Although teachers grudgingly accepted this decision, a sense of distrust burgeoned in the teachers.

> *"I was teaching the chapter of biodiversity to the 9th class. I gave them an activity on herbarium (…) this was quite easy- (…) Next day the Principal called us and told us that 'what have you given to the students, I am getting so many calls from the parents that this is too difficult for them. (…) This is a waste of time and other things'. Ultimately we cancelled that activity, although this was a very simple activity."[Andy-I2-R27-28]*

This further led to an environment of inhibition amongst teachers to introduce any SSIs-related activities. This was clear in Andy's interview, when he showed his resentment against the unsupportive behaviour of the school leaders. He did not accept what he termed as school principal's "haughty attitude" towards his teaching methods. He talked about this behaviour in other part of interviews too. He felt belittled as school leaders considered parents' requests more important than teachers' decisions and made teachers feel disregarded.

> *"We were ready to have one more activity related to this one [SSIs] only. But no one even tried to understand the objective behind the activity. Instead of asking us the objective and telling the parents about the objectives of the activity, the authorities [school principal] told us to stop the activity. If authorities are not cooperative, then what can we do? We should have been asked about the benefits of the activity, but no one bothered to ask. Why should I bother about trying new methods when no one appreciates or care? They (School leaders) just want good results (in terms of marks) and I will provide them with that only. " [Andy-I2-R29]*

Another important aspect of leadership that impacted the teaching is the response or appreciation the teachers received from their leaders. The response of school leadership towards teachers had a significant impact on teachers' morale and

self-efficacy. Positive acknowledgements from leaders were taken as an intrinsic reward for teachers and motivate them to achieve the collective goals of school. The collective goals in Green schools especially seem to directly influence the teaching of SSIs. Pam and Jasmine reflected on the positive impacts of the appreciation they get from their leadership. Their leader believes in continuous reinforcement for not only students when they achieve well but also for teachers at their achievements. The "small gift" although could be categorised as an extrinsic reward but for teachers it meant more in sense of satisfaction and motivation than the extrinsic value of the gift itself.

> *"(…) whenever a teacher does something good, (…) we get a small gift for the good work we have done. Our principal (…) gives us a small certificate of appreciation for even a small good thing I do. Just shaking hand with a director of the school is a great feeling and when he says good about your work, it is motivating. These small gestures make us feel so special. (…) Our director says it is the teachers who have worked so hard to get these results. (…) And maybe that is why we are able to put our best foot forward and try to give the best in everything." [Jasmine-I3-R26]*

Apart from the appreciation from leadership, it is also important for teachers to feel that leaders do not doubt their capabilities and fully trust their judgement. The feeling of being continuously under an observation makes the teacher very uncomfortable and they need to feel the trust in them from the leadership. Jasmine compared two contrasting situations from her previous and current leadership.

> *"Initially the school where I was working before used to have cameras in every corner of the school. So when someone suggested to our director, that they should have cameras in the class. Our director said I am not playing a game of catch the thief, and neither am I police. I will love to trust the teachers, that they will do their job without any eye on them." [Jasmine-I3-R24]*

A positive reinforcement to the teachers that gives them a sense of belonging and that they are contributing to the success of the school encourages them

to put extra efforts in their work and explore more ideas for teaching in general (Mulford, 2003). When teachers are given freedom without much intervention, as in Jasmine's case, this helps them to come up with more interesting projects or activities for students to have a better understanding of SSIs and awareness of interdependence between science and society. This although is true in Jasmine's case cannot be generalised to all the teachers as every individual might behave differently with freedom, depending on the teacher's identity.

> *"(...) after coming to this school, I had a word with my head and then she said that if you have that thing (research-mind set) in you then why not explore it along with the teaching." [Jasmine-I1-R12]*

> *"In the previous school where I was teaching, I was not having that much freedom to initiate something new [projects or activities related to SSIs], so after some time even I lost that zeal to do things differently. After coming to this school I started with so many things, bio-diesel and plant-cloning [are] just few ofthem." [Jasmine-I2-R21]*

The lack of trust and compassion shown by school leadership, on the other hand, can hamper a teacher's morale and can affect her overall teaching in a negative manner. Jane said while expressing her discontentment from the leaders that:

> *"The school counsellor has such an authoritative attitude that she does not want to listen to anyone's point of view. (...) We are expected to stand 7/8 periods in the school almost on our toes. We are educators, even servants; labourers are treated in a better manner [than us]. (...) If I say anything I'll lose my job you know. Who's going to bell the cat [expression for not standing up to the school authorities]? (...)These things are anti-constitutional." [Jane-I1-R1-3]*

The teacher was referring to an incident where she was sitting in the classroom while showing an animated short film on global warming to her students. This was reported to the school counsellor who reprimanded her for it. She appeared dismayed while talking about this particular incident. She added that after the film she had a good discussion with the students, which was ignored by the leader. When questioned further about what are her plans to teach that topic in future? She replied with a firm reluctance to go ahead with the same plan. This further reflects

that the leader's strict attitude towards the teacher without looking at the outcomes of the lesson had a negative impact on the teacher.

6.4.3. Teachers' Authority

At an institutional level, in previous factor the impact of the school leadership style and their decisions, and the authority was discussed on the teaching of SSIs. However, this factor was from the influence of authority of people outside the classroom. Another closely related factor influencing the teaching of SSIs is that of teacher's authority, i.e., the level of authority assigned or assumed by the teacher who's actually teaching in the classroom. The definition of teachers' authority was given by Ingersoll et al. (1997) as "the extents to which teachers influence school decisions concerned with key educational issues and the degree of individual autonomy exercised by teachers over planning and teaching within the classroom". Policymaking authority, as advocated by Ingersoll et al. (1997) should be conferred to the teachers to ensure the success of any policies or decisions by the leaders. As seen in my study, the authority of teachers for decision-making was not equally dispersed. Only a few teachers or leaders had the authority for policy making and the rest had very little influence over the school decisions. Autonomy as referred to in the definition of the teachers' authority by Ingersoll et al. (1997), is the perception that teachers have regarding whether they control themselves and their work environment (Pearson and Hall, 1993). Pearson and Moomaw (2005) also defined teachers' autonomy as a means of freedom from any interference or supervision from leaders, and the other view being the freedom to form collegial relationships for collaborative decision-making. Teachers' autonomy or the lack of it is a major influence on the motivation of the teachers.

Three out of five schools in this study followed a process of roughly outlining the teaching plan for each grade at the start of an academic year. School leaders had the authority in these meetings on designing the teaching plan for the upcoming academic year. The subject teachers were represented by the subject heads in these meetings who assumed the authority (authority conferred by school leaders higher up in the hierarchy than subject heads) to make decisions on the behalf of subject teachers. This has been discussed in detail in leadership section.

During the academic year, there were monthly or biweekly meetings between subject teachers and subject heads to work out on the minute details of this plan. However, the authority of the teachers in these meetings was not equal.

For instance, in Modern High school, in an interview with the science subject head of middle division (Paula), she mentioned that this pre-decided plan was chalked out between all the science teachers once in a fortnight. She hinted at the decisions being made in a democratic manner, with consensus of all the teachers. She also hinted at an equal opportunity to all teachers to suggest and advice for any changes. However, it was contradictory to the findings from her other interviews and other teachers' (from the same department) interviews. It was apparent that Paula's authority was responsible more than any other teacher (who was interviewed in this study) for making key decisions. This was confirmed in an interview where she emphasised that whenever she finds something interesting for the students, for example, a presentation or a video regarding SSI she would ask other teachers to follow that. She, being a subject head, also had the authority to arrange for inter-disciplinary teaching where she would collaborate with language or geography teachers to hold debates or discussions on SSIs with the students on the specific topics prescribed by her. Additionally, she had the authority to organise any special activities or visits for students, which she felt would help them understand things in a better fashion.

Annie, a science teacher in the same division as Paula, felt that she lacked the authority to introduce any resource or a method on her own for teaching SSIs, even if she felt that would "*motivate them [the students] and encourage them to work further and give them something to work on little more" [Annie-I1-R13].* She wanted to introduce certain videos to show to students, but then she would "have to take special permission" from Paula. In order to avoid any inconveniences of taking permissions, she followed the prescribed resources and methods from the collaborative meeting. This reflects that she ceded her authority to avoid the process of taking any formal permission from Paula. Teachers' authority is linked to teachers' commitment (Pearson and Moomaw, 2005) and the lack of authority to Annie led to less commitment towards teaching of SSIs. The need for 'special permission' led to less experimentation in teaching by the teachers as they felt lack of freedom to introduce

their own ideas, in addition to the prescribed methods and resources. Even at other schools, such as Rockford, teachers felt lack of authority in organising special activities or trips if they feel students could benefit from them. *"Our school does [arranges trips]. We have our environmental manager [Victoria] who takes care of all this, and is in charge of this. (...) Our school initiates these things; however, if I want to do anything on my own, I don't have any say." [Jane-I2-R12]*. This also highlights an interaction between the two factors: teachers' beliefs and teachers' authority. As mentioned in teachers' beliefs Victoria strongly believed in sensitising environment-related SSIs to students and was largely committed to it, which was noticeable due to her continuous participation in national level environment support groups and activities. This was largely possible because of the authority conferred to her by the school leadership. She was able to take most convenient path based on her teaching beliefs due to her authority. Her commitment and teaching success might have been different had she not been given enough authority, despite of her strong beliefs.

In contrast to these schools, Springdale teachers claimed that they were accorded equal authority and teachers had the authority to deviate from the teaching plan set at the beginning of the academic session until and unless the curriculum was covered. Teachers were given enough freedom to experiment or introduce their own teaching methods or resources for teaching SSIs, if they felt like it. This support from the department subject head infused a sense of motivation and confidence in the teachers, and they experimented with their teaching methods to get the best method for the students. For instance, Jasmine was able to introduce many extra projects such as the cloning and bio-diesel projects on her own, owed to the authority she was accorded in her working scenario.

> *"See if you [teachers] are getting freedom from your heads, no one is interfering in what you are doing and how you are teaching then it is always a positive thing. See they do keep a check, they do expect us to perform our best, they do expect good results but they never force us or I should say impose their method or their way of thinking on us." [Jasmine-I3-R9].*

Pam also talked about the 'freedom' that they are provided with, so that they can experiment with the new methods of teaching but not on the cost of compromises with the curriculum followed.

> *"They have given us free wings, we can do howsoever we wish to until and unless [till the point] we are within the frames of the curriculum. If you want to overstep the frames of curriculum, that's still ok but there, should be no clashes between the student's expectations and the teacher's expectations". [Pam-I1-R17]*

Teachers' autonomy as discussed in the definition of teacher's authority is constrained by the interference from the leadership due to their result-oriented approach. Rockford followed an oligarchic style of leadership. Hence, those teachers who were not bestowed with the authority to take decisions at departmental levels reportedly felt frustrated. Jane expressed in her interviews that she experienced pressure of not only producing desired results, but also achieving those results using prescribed lesson plans. She recounted her experiences with fellow teachers, where they follow the prescribed lesson plans with "*blinkers on*" and *"don't care what does our lesson expects, they just see what school authority (subject or department heads) is saying but not what's good for children." [Jane-I1-R7]*. According to her, this impacted teachers' personal teaching goals and lack of a 'feeling of satisfaction' on blindly followed the prescribed lessons plan. If the teachers fail to produce the desired results then they fear of an action against them.

> *"The authorities [school leadership] just want results, and they won't see students are not studying and would blame [the] teacher instead." [Daisy-I1-R51].*

For instance all the teachers, except a few, interviewed at Modern High and Rockford schools experienced a sense of restrictiveness and pressure due to lack of autonomy, or interference by department heads. The exceptions were Paula and Victoria, as they had autonomy assigned to them by the leaders. The department heads tend to overlook the 'benefits of students' with inflexibility in their designated paths and as Nancy stated *"we as teachers have to constantly struggle for approvals and permissions for any additional activity or project they want to conduct for the*

students". [Nancy-I1-R17]. This curbs the creativity in the teaching learning process, as teachers cannot come with any 'innovative' teaching methods and if they try to do so they feel being constantly monitored by the authorities. The feeling of being closely monitored is not just limited to authorities directly, but also from the students, as authorities seek regular feedback from the students about a teacher's performance. *"See students have to give feedback and if you scold them for their own good, still they'll give you bad feedback." [Daisy-I1-R51]*. Hence, the teachers feel more responsible towards achieving the targets set for them and focus on teaching scientific canonical facts deemed important for exams, rather than focusing on other ethical and moral aspects of SSIs. *"The only question they'd [authorities] ask is why did not you give 10/10 marks. The only concern is getting good marks; no moral values, no social responsibility." [Andy-I4-R21].* The lack of authority to teachers and the feeling of being closely monitored are further reaffirmed in the following excerpts from Daisy and Andy's interviews.

> *"If I give no marks to students not submitting assignments, then I'm creating problems for myself, as a letter would be issued on my name that I did not produce good marks. How can I bring them on right track? Authorities just want good results, and in result we teachers are like beggars in front of students asking for assignments." [Daisy-I1-R51]*

> *"See every teacher is having their own performance chart also. It is also mentioned that this particular class taught by this teacher of this subject was having majority students in A1 category. This in A2 and if more students are there in B1 and B2 category then, it is also written there that result should be improved; 'result is not satisfactory'. Then what can we do, our life is in students' hands. Yes and that is a major problem. This is the reason why teachers and students are getting confused. Or I should say that if the students are getting confused, then the teachers are accused." [Andy-I2-R15-16]*

Teachers who feel their autonomy is challenged by the interference of others tend to feel isolated from the school authorities (Firestone and Pennell, 1993). Such teachers might be less inclined towards contributing to the organizational goals, but may be still be committed to teaching goals and welfare of students. Andy and Jane are such examples in this study, as they felt their autonomy was challenged by interference of school authorities at some point. Hence, both the teachers felt

burdened by the collective goals of organisation and felt isolated of it but still cared about the students.

6.5. Student Response

The primary focus of a teacher is to guide the students through the teaching-learning process and a student's response to the whole process is a vital component of teaching. Similarly, in this study the response of students towards teaching of SSIs, and their engagement level in SSIs-related activities emerged as one of the major influencing factors on the teaching of SSIs. It must be noted that the evidence for response of students is from teachers' perspective and not directly from the students. So, any students' response in this section is sole representation of teachers' perspective. Teachers feel responsible for students' learning and students' responses are a key feedback to a teacher while teaching or for instance experimenting with any novel teaching method. Every teacher has certain expectations from students related to the response they give towards teaching of any topics. These expectations are linked to the teaching goals, previously discussed, of a teacher. For example, if the goal of a teacher is to make students aware about a certain SSI, then teachers expect their students to respond in a responsive manner, so that the teachers get the confirmation that they are on the right path to achieve their teaching goals. The teaching goals and students' responses have been seen to share a mutual impact relationship in this study.

Some teachers in this study aimed at engaging students in SSI topics and instigating certain interest towards different facets of SSIs, such as ethical-moral aspects, scientific knowledge; while some other teachers were mostly or very concerned about students' grades in the examination. For instance, Jasmine's primary teaching goal was to engage students in the SSIs-related topics and garner their interest with more activities concerning SSIs. The students' positive response to her efforts encouraged her to take further initiatives towards teaching SSIs.

"And the thing is even students become passionate towards the same when they see that you are so passionate. The five kids with who I was working

on the bio-diesel project they are much more passionate than me now regarding the project. Now two of them are planning to change their stream to humanities, but they are still so passionate about the project that they had a word with the principal mam to continue with the project and I really feel good about that. This makes you feel that you're on the right path."[Jasmine-I1-R12]

Another teaching goal emphasised by Jasmine was: *"My basic objective is to create interest, (...) so first of all to develop that interest is very important. So you need to have some attractive activities, later on the objective or say the concept also becomes a part of their interest." [Jasmine-I3-R3]*

When she invested her efforts for garnering their interest, students responded with enthusiasm and interest. Although, both Jasmine and Pam mentioned that the initial interest from students is more towards the activity part but later it develops into the content part of the activity as well, as they are more informed about the content of the activity.

"Initially they enjoy the activities. But later on when they understand the objective behind the activity it becomes informative also and it interests them also." [Jasmine-I3-R2]

By contrast, Andy's main teaching goal was to secure good grades for all his students. He did not place much importance to any alternate teaching methods or activities other than his usual explanatory lecture method, as he did not consider them beneficial for securing good grades. Andy further stated that whenever he assigns students with additional assignments on certain topics, most of the students do not care to understand much about the topics and rather *"students either copy paste it from the internet or from their peers" [Andy-I1-R23]*. Students, according to Andy, are never interested in the specific activities for SSIs and remain undisciplined during any such activities. So this act is an additional deterrent in Andy's not focusing on SSIs-related activities. Consequently, he did not initiate any interactive activity (except, asking the questions about the canonical facts taught previously, with an aim to check the reproducibility of the facts) with students.

"And I tell you this is what I feel, [students] have complained about me also that sir's half energy and time goes in marking the question and answers or we don't like the teaching, as it is not so interactive. But I think this is because, they want to create indiscipline and in my lecture they don't get an opportunity to do so. See everyone is having their own perceptions, so I don't care about the complaints I just believe in getting good results and maintaining discipline in the class." [Andy-I2-R38]

Here in this example, an interaction between the teachers' beliefs about the students and the students' response expected by the teacher is highlighted. As discussed in Section 6.2.2. Andy believed that it would be a "waste of time" to teach SSIs to students in an interactive manner. The students' response expected by Andy in this case, reaffirm his beliefs about students presented Section 6.2.2. In comparison to Jasmine's example mentioned above, Jasmine's SSIs teaching was impacted by the actual students' response whereas Andy's teaching of SSIs was impacted by the anticipated response from the students, i.e., indiscipline. As highlighted in the subsequent dialogue, his teaching was further impacted by the notion of loss of control over the context being discussed in the class. This concurs to the findings of Day and Bryce (2011) that teachers always wish to remain in control of the content being discussed in the classrooms, and they do not want to be in a state where the students have more content knowledge of the topic under discussion than the teacher. This also brings me to a point deduced during the analysis of my data that the influencing factors are highly interrelated to each other. That means the impact on the teaching of SSIs is mostly due to interplay of various factors. For instance, here the impact was due to the teachers' beliefs about students, expected students' response or the past experiences with the students' response (e.g., indiscipline), and teachers' determination to remain in control of the content discussed in the classroom and the discipline in the classroom.

"So, we are not doing all these debates most of the time because our students are not the students meant for debates. It is risk and is dangerous. [After saying this he started laughing] Secondly, they are undisciplined, (...) and whenever you try to discuss anything may be like a general topic, they take the

topic up to some other level where you don't want to go. (...) So it is better to avoid it?" [Andy-I3-R1]

He referred to some instance in the past where he tried to conduct interactive discussions with students, but stopped it due to the discipline requirement. He did not want any argument during his class, and considered a discussion "healthy" where there was no argumentation. After this, he resorted to the explanatory lecture method and did not experiment with any interactive methods.

"Healthy discussions in which students are listening to teachers and other students' opinions without any arguments, and accepting other points of view rather than interrupting and not letting others speak, basically when everything is under discipline." [Andy-I3-R9].

In an anticipation of indiscipline, he modified the flow and the outcome of the discussions or debates. In order to avoid any indiscipline, he presented certain views during discussions, i.e., the "middle way", that he himself did not completely believe in.

"So at that time [point of any disagreement in discussions] it is like we have to find a middle way. Even if I don't agree with that middle way, I will say it because you don't want students to argue or fight." [Andy-I3-R7]

The degree of agreement of students' responses to the teaching goals of teachers impacts the degree of flexibility the teachers show to certain aspects (exemplified later) which in turn impacts the teaching-learning process of SSIs. If the students show a high degree of agreement to teaching goals of teachers, then teachers tend to be flexible in certain aspects, which positively impact the teaching learning process of SSIs. The inverse is also true when the degree of agreement is low. For instance, Jasmine gave out assignments to her students related to genetics on topics such as genetic manipulation, cloning, and stem cell-research. She wanted her students to be aware about these issues. One of the students prepared an extensive presentation on ethical and moral aspects of SSIs, and Jasmine was extremely happy with his assignment. Since the scientific content was missing from his presentation,

she ensured the inclusion of scientific knowledge in a flexible manner. She agreed to the students' request to let him keep his presentation as-is, and allowing him to do another assignment just concerning scientific content.

> *"I told them that they can choose any application and also address ethical issues in their projects. (...) one of my students made this brilliant project on ethical issues regarding all the applications, so instead of focusing the project on the scientific knowledge, he focused on the ethical issues related to GMOs (genetically modified organisms), gene therapy, BT (Bacillus Thuringiensis), cotton, transgenic animals. I was really impressed, but still they have to perform in the exam and the questions are related to the scientific knowledge, so I told him that he should include scientific knowledge also. But he said that he will give a separate viva or a presentation on the scientific content but he did not want that assignment to be altered." [Jasmine-I2-R7]*

The positive students' responses consistent with teachers' teaching goals were also one of the driving factors that affect the teachers' teaching of SSIs. Teachers prefer to take the positive response of the students as a re-affirmation for their efforts and this motivates them too.

> *"(...) previous class had students who wanted to learn something new, they used to be so curious that I use to push my own limits so that I can accommodate that much knowledge and answer their questions beyond just the prescribed science curriculum. In fact it was a two-way learning process; I had learnt a lot of new things from that batch. " [Jasmine-I2-R11]*

Also, Katie assigned a project to students where they had to interact with local farmers in a village and make them aware about the harmful effects of pesticides and insecticides. She reported on a development of students' responses and the SSIs-related activities; in a sense that initially students weren't very enthusiastic about the activity but during the activity they got really involved and that led to the success of the activity (Katie was satisfied with the level of students' involvement and the outcomes) and in return the students were able to very closely observe the implications and multi-facets of a SSI and their reaction gave Katie a confidence to carry out the activity with future classes.

> *"We initiated the project, (...) our students went to the villages for the first time, then there was not much difference, then they went again and reminded them all of the stuff again. . . the next time they went, we could see the impact and the students were also so happy, they felt like 'yes' we have made a difference. This acted like a booster for them and they were like when we will start our next project. I tell you one thing, when we teach these things in the class then they learn it and may be understand it but just on the superficial level." [Katie-I1-R12]*

The previous group (from previous year) Jasmine mentioned were really interested in discussing about SSIs, and invested a lot of effort for gathering more and more information for discussions. They had 'proper discussion', discussed further, as termed by Jasmine and she had to commit more towards that class. This leads to a spiral of reinforcement for students and teachers, where Jasmine also had to read more to increase her general knowledge about all the aspects related to those issues, as students constantly asked her many questions of the sort *"Madam why has government banned cloning in our country?"* She also mentioned that she had to herself first consider SSIs from various angles as due to the enthusiastic involvement of students they liked to discuss many different facets of SSIs and Jasmine wanted to prepare herself for any possible situation.

Pam shared similar views in her interview, where she is driven by student response and feels the need to adapt her teaching methods if students are not responding in a manner, desired by her. *"When I feel that whatever examples I'm posing for them, whatever I'm teaching, preaching them, shows them, that I'm not getting the desired results. (...) I'd start working via another method." [Pam-I2-R2]*

"Proper discussion" mentioned by Jasmine refers to a well-informed discussion on SSIs including not just scientific facts but also moral and ethical aspects of the SSIs. According to her, the SSIs, such as the use of pesticides, are very well known to students due to the wide media coverage and that they are widely discussed topics in Indian society. This helps them have better understanding of the topics to form informed opinions about such topics. However, topics such as,

cloning, that are not widely discussed in the Indian context, are relatively new to students and they usually just gather scientific facts from the Internet or have vague ideas from movies such as 'The Island' which they use to form opinions. They are unable to hold a "proper discussion" as their opinions are not so well formed.

By contrast, for Andy since students' responses was not in agreement with his goal of maintaining discipline, he did not show much flexibility in his approach and did not conduct many activities specifically targeted at overall awareness of SSIs.

> *"I do appreciate when students genuinely have some problems or queries to be discussed and they do but just because of few students we are not able to do so because they will create indiscipline. When I am teaching I want a pin drop silence in my class." [Andy-I2-R39]*

Another facet, in student response is that of response of low-attaining students. According to Jasmine, the involvement of a majority of the students in the class is more during interactive activities and that encourages her to conduct such activities. The students that usually do not perform well in exams or show less engagement during regular teaching are also interested and engaged in SSIs-related activities.

> *"Initially, it was the activity only. They are quite excited when they are doing things by themselves and even the low scoring students, are also getting completely involved. (…) They do better, when we are trying learning by doing kind of methods rather than simple teaching. So it is a very positive thing (…) I think the mediocre students understand things beyond that cramming, they have that 'out of box' thinking. I have realised that we should not ignore these kids, may be they are not having the proper medium to express their talent or capabilities. But we should definitely encourage them." [Jasmine-I3-R18]*

The interpretation of 'out of the box' thinking from Jasmine can be made by from her interviews, where she explained from her experiences that the low scoring students have the intellect and ability to relate to things beyond textbooks. She mentioned that attaining low grades can probably be attributed to their low

retention power, but then such students participate actively and do well in activities like projects, debates, discussions, etc. where they get a medium to express their ideas.

This also underlines the impact of students' responses to how a teacher teaches. The response from students and their expectations makes a teacher think about her methods and activities and helps her adapt her methods according to the students' response. Jasmine introduced a role-play activity for teaching effect of various gases on our environment, and she has carried it forward in each class she teaches because of the positive response from the students. Another facet to the factor - students' response is that there exists a bidirectional relationship between the teaching and students' response (Ryder et al., 2014). On one side as illustrated in this section, students' response influences the teaching; on the other hand, the teaching shapes the students' response. For instance, if Andy did not enjoy the interactive part of teaching SSIs that was reflective in his students as well and since Jasmine went out of her way to make SSIs lessons interesting for her students, the students responded to that positively and enthusiastically.

6.6. Pressure for high attainment

The pressure on teachers to ensure good grades for students in exams was one of the most common factors influencing the teaching of SSIs encountered in this study. This pressure usually coming from the school leadership or parents came in the form of complaints to teachers, if the students did not attain good grades. Leadership also exerted pressure, in some schools, by maintaining results database of all the teachers. Ekborg et al. (2013) found this pressure on teachers as a factor as a possible source of tension between covering the canonical content in curriculum and developing the skills, such as reasoning and decision-making in students.

The effect of pressure to obtain good grades on the teaching of SSIs was evident in interviews of all the teachers in this study.

"It (The education system) is more grades, theory oriented but less towards practical work and actual learning." [Andy-I4-R17].

As mentioned at the start of the chapter, there are certain overlaps between the influencing factors, which are also true for this factor. For instance, sometimes students consider SSIs related topics or activities as subservient to other topics, and do not respond enthusiastically towards the teaching of SSIs. Students, as accounted by teachers, are primarily interested in topics that are deemed important for exams towards the end of an academic year. Additionally, as indicated by Pam and Jasmine, due to the large amount of the content in the curriculum students might not find enough time to cover all the topics, and choose to be less interested in some of the topics. The students' response towards SSIs issues before exams also impacts the teaching goals and methods of teaching, as consistently observed in this study.

"Students are least interested in these topics, there's no exam point of view in there for students." [Pam-I1-R13]

"I have conducted such debates/activities two to three times in the past, it did work to some extent but we're stuck from exam point of view. Exam point of view restricts them a lot. They'd like to play safe within that sphere of exam curriculum, and anything beyond that is unacceptable for them because they already have a lot on their plates. And all these extra activities, if they know this is not important from exam point of view, they feel 'what's the use of it?" [Pam-I1-R22-23]

"And the problem is students are not so passionate about all this, they are more into grades and marks."[Jasmine-I1-R10]

Most of the teachers stressed that the grade-oriented thinking of students hampers the 'actual learning' of students, and the appreciation of the various aspects related to SSIs. For getting good marks in exams, both students and teachers emphasise upon 'learning' of canonical scientific facts, rather than 'understanding' the social ramification of such issues, and the ethical-moral dilemmas attached to them. Such a practice is in coherence with the findings of Reis and Galvão (2004b). They found that the focus on exam success leads to an image of science among

teachers as merely being a catalogue of canonical content that the students must memorise and repeat in exams.

> *"Ultimately, if I'd be teaching this topic or not, depends upon exams. How much should I teach for this topic for students to learn, I'm using the word learn not understand, is based on what's going to feature in 10th board exams." [Pam-I2-R15]*

Jasmine agrees to this, and believes that students are not passionate towards these issues as they are towards achieving grades. This response from students, along with certain other factors seen in the data analysis such as parental pressure, the large size of the curriculum, success in competitive or external exams has a direct impact on the teaching goals of teachers and their approach towards the teaching of SSIs. She believes that students are running a "rat-race" because the system she believes *"is based on how good you are in theory and how good you perform in exams. It is more about the rat-race, the race to get good marks, get in competition, have the best of the careers but the basic understanding is still missing." [Jasmine-I1-R15]*

The pressure of success in exams also results in teachers changing their teaching goals towards the end of an academic year. When exams are approaching teachers they just focus on regular teaching of topics that they think will feature in exams. According to Jasmine, towards the beginning of an academic year teachers are more interested in teaching new things to students using more interactive teaching methods but towards the end of the year they change their approach and are more concerned about finishing their curriculum and preparing students to get good grades in exams.

> *"We try our best to make the kids aware of the things that are going about but not at a great level, may be the restriction of time and curriculum is there. (...) And the problem is students are not so passionate about all this, they are more into grades and marks." [Jasmine-I1-R10]*

The teaching activities, such as debates and discussions are avoided by teachers on topics not important for exams, and are completely stopped before exams.

> *"(...) when exams approach we shun all the activities and concentrate on the exams. Rest [of the time] the activities keep on going on. So as the exams approach it is about "tightening the noose". So we shun all activities, which are non-value adding [not helpful from grades perspective], or require more time. But this happens only towards the end; rest of the time it is all activities" [Pam-I2-R17]*

Pam reiterated this and mentioned the additional pressure due to board examinations on the teaching of SSIs. In the Indian education system, in 10th standard (age group 15 – 16 years old) and 12th standard (age group 17 – 18 years old) exams are conducted by national education boards and are external examinations. The impact of external exams has been discussed further in assessment system factor. Pam mentioned that she sometimes skips a topic if it is not relevant for 10th board exams, and this begins from 6th standard onwards, i.e., certain SSIs related topics are not covered in enough detail despite being in curriculum in 6th – 9th standards if they're not important for 10th board exams.

The pressure for exam success also mounts from the school leadership, as leaders want to maintain a positive local identity. This local identity concerns being recognised as a centre for achieving excellent academic results. Schools advertise their board exams results (10th grade and 12th grade results) in local media every year, to showcase their identity as academic high achievers. This behaviour was witnessed in four out of five schools in this study. It wasn't encountered in Springdale school.

> *"Our leaders want us to only focus on good marks in the subjects. They want to create a picture of them as a school with excellent board results. (...) They need some material to publish in newspapers [the schools with excellent board examination results publish these results in the local newspaper as a publicity] so that more and more students can take admission in our school." [Kady-I2-R4]*

"I don't think anyone is giving them difficult tests [referring to the internal assessment tests conducted by the schools from which a certain percentage of marks are accounted by the external board examinations. Most of the schools conduct easy tests so that their students at least have maximum possible marks from these internal assessments.] because most of the schools are private schools and they are more interested in having more and more students in A1 and A2 grade list because they are having this information in the brochure, prospectus of the school, in the advertisements in the newspapers, in media." [Andy-I1-R14]

6.7. Resources

Firestone and Pennell (1993) (p. 508) described resources as the "material and institutional means through which teachers are able to accomplish their tasks and experience intrinsic rewards". They delineated five different types of teaching resources in their study, these resources were; an orderly environment, administrative support, adequate physical conditions, adequate instructional resources and reasonable workloads. Most of the contents of these have been discussed before in different sub-sections (leadership and authority), so this particular sub-section will focus on instructional resources and reasonable workloads.

It was found during interviews that the resources especially textbooks have a major influence on teaching of SSIs, as textbooks act as a blueprint of the teaching in the classrooms and if textbooks focus on SSIs and the activities are related to that then teacher also tend to focus on them. However, certain instances were witnessed in this study where teachers considered NCERT books (books prescribed by national board for teaching in CBSE schools) as being "out of date". This was evident in Daisy's comment when she mentioned that

"NCERT books should be revised; the things in the books are so old. Books should feature some newer discoveries (...) that students feel like learning when they open the books. NCERT has so old data and discoveries. CO2 level mentioned is 0.03% but it has increased now. It has to be changed." [Daisy-I2-R43]

Andy also shared similar kind of views. He revealed that: *"It is almost for all topics if not for extra explanation, than to update our knowledge we need to refer to other resources or books or Internet." [Andy-I2-R5]*

The teachers also highlighted that NCERT books lack 'sufficient' explanations of SSIs especially in terms of providing them real life examples. Katie brought this issue to light where she disclosed her apprehensions regarding dissatisfaction of students while teaching SSIs. This reply was in reference to a term "good content" that she repeatedly used to address the content that she prefers to use for teaching SSIs. She said that

> *"Students are never satisfied when I teach just from books; they feel satisfied when I relate the content to their lives. That's why I prefer using extra books and latest examples from internet. [In this way] they're interested in the topic (...). If a teacher is just explaining content from the NCERT books without correlating it to their lives or the application part then they don't like it." [Katie-I3-R29]*

This impacted the teaching of SSIs in an adverse manner as teachers had to gather more information from other sources which weren't always possible due to time pressures and extra burdens on teachers. This finding is in coherence with that of Firestone and Pennell (1993). The authors reported that teachers felt distracted if they have to invest their time and energy to think about other resources or methods to teach. The non-availability of instructional resources was unanimously reported by all the teachers who were teaching in the C.B.S.E. affiliated schools where a prescribed textbook is followed. Andy also reiterated the insufficient content knowledge issue. As discussed previously Katie had concerns about dissatisfaction of students, Andy on the other hand had issues regarding students' performance in competitive exams. He said that:

> *"In NCERT there is basic of everything, many times extra details (...) are missing.(...) Students are not clear about the concepts, so we follow other books where proper and extra information is given. We have to follow other reference books (...). This also affects their performance in the exam." [Andy-I2-R4]*

However, teachers of Springdale had a different opinion about instructional resources. All the three teachers reported that there were ample amount of resources available. This could be attributed to the fact that there is no prescribed textbook by I.C.S.E board that teachers need to follow and hence, teachers are used to following a combination of books for teaching.

Reasonable workload is another factor that impacted the teaching of SSIs in this study. A teacher's workload is not only described by the teaching and the additional non-teaching work that teachers are expected to do but also includes class size (Firestone and Pennell, 1993). The teachers are restrained by a large pupil-teacher ratio in classrooms, as it hampers their ability to conduct any interactive activities with the students. Teachers need to have a sense of control over the classroom (Bosser et al., 2015, Day and Bryce, 2011) while conducting any interactive activities and with large classroom strengths it becomes difficult for them to maintain decorum in the class.

> *"If the class [size] is less than the discipline problem is less. You can do more activities where students can involve more. I have seen that if you discuss things with students then the response is quite good but if everyone is speaking loudly, not waiting for their turn to speak, not listening to others properly; this all leads to indiscipline and that we do not want." [Andy-I2-R33]*

The large class size was only seen as a major influencing factor in Modern High school and Rockford, as for other schools such as Springdale and Queens High school it was a conscious leadership decision to contain the pupil-teacher ratio to a reasonable level, and was 25:1 at the time of this study. Blue Bells School, being a relatively new school, did not have many students enrolled. So, the pupil-teacher ratio was even less than Springdale and Queens High schools.

At Modern High and Rockford the pupil-teacher ratio, at the time of this study was 50:1 (i.e., 50 students in a classroom taught by a teacher). Teachers at both schools experienced difficulty in conducting the activities such as discussions and debates, as they felt difficulty in maintaining control and secondly, they felt that

it is difficult to give an equal chance to each and every student in such activities with a greater number of students involved.

> *"See conducting all the activities is not practical in Indian scenario. In our school only we have 52 children in one class, so we cannot conduct an activity in one day. Because, if someone does not get a chance in the activity they are demotivated for the next time." [Daisy-I1-R21]*

> *"As a teacher, we have to cool down the students and tell them to speak on their turn. This kind of an activity can only be carried out of there are around 20 – 25 students. We cannot do it with 50-55 students (...)" [Andy-I4-28]*

Hence, the teachers felt that if the class size had been lower than that would give them an opportunity to discuss things with the students in an effective manner that can lead to more long lasting outcomes. The effectiveness, as referred by Daisy, is in terms of interaction level of students during the activities.

> *"Out of 52 may be 5-6 children did not get anything then we can call them in free period. But if strength [the class size] is less we can do remedial teaching, but with so much students it is very difficult." [Daisy-I1-R50]*

6.8. Assessment System

One of the factors discussed previously regarding pressure of high attainment in exams covered the pressure exerted on teachers to help students perform better in exams. Another relevant factor delineated in this study is that of assessment systems themselves, due to the perceived shortcomings in the assessment system. The assessment system followed in schools was the system prescribed by the respective national educational boards that the schools were affiliated to. The different educational boards, their functioning, and the different assessment systems prescribed by them have already been discussed in detail in Chapter 4. One particular assessment system, named Continuous and Comprehensive Evaluation (CCE) system was considered as problematic by few teachers teaching in CBSE schools. The teachers conveyed that it created an extra burden of work for them due to the fairly

rigorous assessment system and the extra work entailing the assessment system that affected the teaching of SSIs in broader horizon. However, not all the schools reported problems with that, and in fact only the teachers teaching students more than 14 years old, in particular described problems related with this assessment system. Hence, it could be that the problem lay within the implementation of the assessment system by the departments, rather than being a problem of the assessment system itself, as portrayed by some of the teachers. These teachers reported feeling 'worse than a daily construction worker' or that they were 'doing clerical jobs' while teaching in the current system, and hence they were unable to devote enough time to prepare instructional material and conduct activities related to SSIs. The CCE assessment system in CBSE, as reported by the teachers from Modern High school's science department (teaching students more than 14 years old), requires a lot of extra work from them and students. The teachers said at different instances that they have to prepare questionnaires and correct students' assignments, and students need to finish a large number of assignments for all the subjects.

> *"Just think how much burdened we are and students are also burdened (...) just to get 10 marks, he has to go for 8 to 10 different things to be submitted." [Andy-I2-R18].*

The teachers feel constantly burdened with the extra work. Andy mentioned that, "Teachers are less focused on teaching and more focused on completing these reports." The term 'reports' here is in reference to the documented record that teachers have to maintain for the submission list and the assigned marks in the tests, assignments and projects. The teaching of topics related to SSIs and especially the implications on society and the ethical-moral aspects of SSIs suffer because of these extra burdens on teachers and students.

> *"It is very difficult for us and if in FA3 (a tri-monthly assessment, Formative Assessment) one assignment is there, one test is there, one project/activity is there and then for each class it is 50 x 3 that is 150 records. And suppose I am teaching 5 or 6 classes that is 250 or 300 students then we have 750 to 900 records. It is a teacher's responsibility to collect these from the students, arrange them in folders. Right now I am having more than 250 folders with me. It is not a teaching job anymore, it is a clerical job." [Andy-I2-R17]*

"We have to do this clerical job to maintain all these records because there might be a random inspection from CBSE, or higher authorities. They can just ask for files from particular roll numbers; we have to keep all these ready else teachers are the ones who are defaulters" [Andy-I4-R14]

Daisy, teaching in the same department as Andy, had more problems with the nature of assessment rather than the extra work entailing the assessment system. She mentioned the importance of within classroom day-to-day assessment rather than assessing the students based on pre-announced assignments and tests. When asked about how this affects her teaching of SSIs. She said that:

"See these assignments and projects should be stopped as they're [students] not getting anything out of it. They're doing it as a formality or you say half-heartedly. The evaluation should be genuine, we can conduct quizzes in the class but then we don't always have enough time for that. See FA's shouldn't be announced in advance, and they should be told that they can have FAs on any day from the topic teacher is teaching in the class. This will make at least 45 students out of a classroom vigilant to what teacher is teaching in the classroom, if they want to get good marks." [Daisy-I1-R34]

These excerpts seem to indicate that she is not deterred by amount of work that Andy was complaining about before, but what bother her are the outcomes of the assignments. This is further supported by the following response:

"FA (Formative assessment) system is not correct assessment system. The assessment should be done during classroom teaching only. (...) But marking students for copying someone's assignment and giving them full marks to them for that, it is fake. If we actually start assessing them then they're not getting good marks in tests. Why? Because they're going to tuitions, and then they do not listen to any one in the school."[Daisy-I1-R45]

Andy repeatedly mentioned faults in the current system in comparison to the old assessment system that was followed before the current changes were applied. His dissatisfaction is similar to MacLure's (1993) findings of the teachers that felt alienated from the current values and practices of the institutions and retorted to

the Maclure's "golden age accounts" that compared the dissatisfactions of the present with the satisfaction of lost past. Hence, it could be the alienation of Andy in particular, or the implementation of the assessment system by the department authorities at Modern High school that the CCE system was impacting the teaching of SSIs, with less and less time being devoted to the interactive activities used for teaching SSIs. *"And what has this [assessment system] caused, from last four to five years, students of 9th (14 years old) and 10th (15 years old) are lacking the spirit of competition. Because now the toppers (high-achieving students) are getting 8 out of 10, and average are getting 7 out of 10 and the low performers also." [Andy-I2-R14]*

All the other teachers from rest of the CBSE schools covered in this study did not complain about the CCE assessment system, except Jane, who had a problem with the repetitive assessment of same knowledge set of students in CCE.

> *"I think vast curriculum [is a problem] as such it is not that much but due to FAs they seem so much. There are so many exams where they are repeated. There are 15-16 chapters, which are divided in 4 each groups, they come in first exam and are repeated in next FAs too. By doing so, you're blocking the time of students to learn new chapters. So the assessment system is also not right. Actually they [CBSE] meant some other thing but schools are doing their own things. Nobody is there to keep a check. We have weekly test for 2 lessons, then we have practical in FAs for other two lessons, but for half yearly exams they are again repeated along with the weekly tests. This is so much burden for students. FA2 is repeated in SA1 (Summative Assessment). When you've already evaluated a lesson, why are you repeating it again in SA1?" [Jane-I1-R7]*

Katie on the other hand, supported the assessment system; as per her experiences this is actually good for students.

> *"We conduct so many things like tests, assignments and all students keep on saying that when we will prepare it, how we will prepare it but we by our experience know that if we don't keep pressure then students don't go and study. (...) Initially I thought this is too much burden even I was against it. Then with time I felt that they become serious only when there is a cycle test [official assessment] approaching (...)." [Katie-I3-R15].*

She also mentioned the positive impacts these have on the teaching of SSIs, as the SSIs-related activities, which the teachers are asked to conduct from the educational boards are made a part of the assessment. And due to the nature of students' seriousness towards the assessment related issues, they are willing to learn more about these topics when they are part of the assessment.

> *"See whenever there is an issue like this especially environmental issues [environment related SSIs], CBSE sends us a circular to conduct some activities with the students so that it develops their mind-set or say gives them that zone to think about these issues and maybe take a message or mind-set with them to their homes. And apart from this, these things are made a part of the curriculum like the assessment system. We have FA's (Formative Assessment) where we include that topic as a part of one of the assessment. See it is both ways, sometimes students are quite interested in such kind of topics as they feel it is their time, sometimes it is like they are not bothered, so when it is a part of the assessment then they listen to you also and take part in the activity also." [Katie-I1-R20]*

Victoria, a teacher in the same school shared similar views. She believed that this new assessment system has open more prospects for the teachers and students to explore. She hinted towards her approach towards teaching SSIs and added:

> *"The best thing is, now it's not the old-school scenario in which we studied. It's just not about answering the questions. Now we can involve students (...) it has become more interactive." [Victoria-I2-R11]*

6.9. Additional factors

This section will address the other limiting factors that affect the teaching of SSIs.

6.9.1. Time constraints

The shortage of instructional time to cover all the topics in the curriculum and to conduct additional activities for better understanding of topics such as SSIs was

found to be a factor that was usually a concern for many teachers. Some of the existing strands of work on SSIs-related teaching have also recognised lack of time as an impediment to an effective teaching of SSIs (Lee et al., 2006). The shortage of time constrains the teachers to prepare instructional material required for activities and consequently, in conducting any SSIs-related teaching activities in the class.

The time constraint does not only impact the teachers' teaching plan but also affects the students, as they have to learn so many different subjects and prepare assignments for all the subjects. This directly influences the interest of students in SSIs and related activities. Some students, as reported by Andy, feel much more comfortable and understand various aspects of SSIs more clearly when they are under no timepressures.

> *"Sometime they do it quite [well] especially those that are given during the vacations. Like we gave a project to the students (...) (related to) drastic effects on environment. (...) So in one activity we can expect them to know the environmental effect and then their moral and social responsibility also." [Andy-I2-R23]*

Teachers feel that their first responsibility is to ensure that all the topics in the curriculum are covered, and hence the focus on SSIs is decreased during time pressures. "*We do try things, add things to make the topic interesting but not [at the cost of] the syllabus that I have to complete." [Andy-I2-R7*]. It must be noted that teachers have used the terms syllabus and curriculum interchangeably in their interviews while referring to the same entity. The teaching of SSIs and the relevant activities are less important when the priority of the teachers is to finish the curriculum and they are considered again once the pressure of finishing the curriculum isover.

> *"I start up with discussions of such topics, but only if I have time. If I have huge syllabus pending, then I won't. And generally we try to leave these topics to the end, because in the end we are almost finished with our syllabus and can afford to get a period or two for discussions or any other activity. The kids can also enjoy and we are also not having tensions to complete our syllabus." [Jasmine-RI3-R19].*

The teachers such as Pam, Jasmine and Katie who considered teaching of SSIs as integral part of their teaching goals also succumbed to the time pressures, and changed their goals whenever there was time pressure to finish curriculum. This also shows a significant variation from what Jasmine reported at other instances in her interviews.

> *"In my case I have seen, when we are talking about genetics (...) I need to give them instructions or say time to prepare for G.Ds (Group Discussions) and then have a proper lecture devoted towards the same. (...) Why will I prefer to waste my entire time on discussions only, when I know I can cover several topics within that time? May be if I work more harder, maybe I will be able to have that small time period which is required to carry on the discussions. But at the end you again have to reframe and redesign, to get that time, but we don't have that much time. And secondly, it is not adding much to the curriculum."[Jasmine-I3-R14]*

> *"I devote just one lecture for discussion so that certain opinions get clarified and later on also during my free time, if students want to clarify something or some doubts remain in their mind, (...) but you cannot hold discussions again and again as the time is quite less." [Katie-I1-R10].*

6.9.2. Pressure of curriculum coverage

The pressure of curriculum coverage further increases in standards such as, 10th grade (15 – 16 years old) and 12th grade (17 – 18 years), when the curriculum is vast and education boards conduct the examinations. Teachers, due to pressure for students to perform better in exams, specifically tend to ignore SSIs-related activities (which are even prescribed in the textbooks) in 10th grade.

> *"Yes, I have tried (SSI-related activities) but we don't try much with 10th standard because the syllabus is too much but we do try with the junior class students from 6th to 8th standard." [Jasmine-I3-R16].*

> *"In 9th and 10th standards we're not able to give such kinds of projects (...) the students in these standards are already much overloaded. The senior students have only 3 specialised subjects along with English and optional*

subject; whereas in 9th or 10th standard they have 7 subjects and some of the subjects have 3 or 4 sub parts." [Andy-I4-R5] The time pressures have been observed to specifically impact SSI teaching-learning activities as teachers choose to ignore these activities, in favour of topics considered more important for exams. "See there are also time constraints, when we have less time we have to rush through the curriculum because we are directed to finish the whole syllabus." [Daisy-I1-R44].

Teachers believe that SSIs-related activities are very time consuming to see any 'good results' (in exams and change in the thinking of students) and to ensure any substantial decision-making capacity in students over such issues. This might be because teachers can easily quantify the level of canonical scientific concepts learning of the students, which is not the case with SSIs.

"See, as I said before it is very less time that we get good results out of such activities and secondly that much time to conduct any activity with proper objective." [Andy-I2-R24].

The notion of 'good results' is related to the teaching goals of teachers. The 'good results' might be related to success in exams, or clear understanding of a moral or ethical viewpoint, social ramification of a particular SSI, or just the controversial aspect of an SSI. The 'proper objective' referred here by Andy is the retention of the take-home message, intended by him as an outcome of the activity, by the students. This objective is referred to as 'message' by Jasmine in an interview, where she mentioned the impact of time constraint on the teaching of SSIs:

"(...) conveying the same message to the kids is a tedious job, it is happening but at a very low pace. We try our best to make the kids aware of the things that are going about but not at a great level, may be the restriction of time and curriculum is there." [Jasmine-I1-R10].

Pam also agreed with this, however she showed a sceptical viewpoint as to whether the students actually carry the 'message' with them despite spending so much time over these activities.

"Whole discussion method is very time consuming, it does impart the value but only within the class, and there is no confirmation if they take it with them to their homes.I would say usually they don't." [Pam-I2-R27]

6.9.3. Expectation of students' parents

The expectations of students' parents also have impact the teaching of SSIs. In this study only adverse effects originating form parental pressure were witnessed. Students' parents judge the amount of knowledge gained and the learning of their students from the grades they attain in the exams. In this case 9 out of 14 teachers talked about the expectation of parents affecting their teaching. This attitude of parents creates an added pressure on teachers to work towards getting good grades for the students, instead of focusing on making them understand SSIs. Jasmine reaffirmed this point in her interviews and in an informal confirmation she showed her discontent due to the pressure situation created by this factor.

"If they are not getting good marks then parents ask, they go and talk to the head teacher. (...) we make sure that the curriculum is finished and the students are performing well in the exams. At times the priority is just the marks, (...); it will all become how much you scored in exams. Parents never appreciate that 'Oh! They did plant cloning in their labs'. But they will question you if their kid is not scoring good marks. Grades are important but that is not the only thing, learning happens beyond the grades also. It is not just about how far you run in the race. It is like a blind race, like a rat race. The more you score, the more you learn [cram] attitude is not good." [Jasmine-I2-R24]

The above excerpt shows the tension between parents' expectations and classroom teaching. Parents tend to disregard the aspect of holistic learning and focus more on the grades of their children. They tend to compare the progress of their children in terms of curriculum and grades to other students. In case they feel that their children are lagging behind in these terms, they create certain kinds of pressure for teachers to concentrate on things, which they think, are more important. Pam explained this from herexperiences:

"I would do these things one, twice, four times but then there are teachers running ahead of me in terms of covering syllabus, and then parents

come and say that this teacher keeps on carrying useless discussions but does not teach actual things."[Pam-I2-R27]

It was also found that the expectation from parents also delimits the teachers' focus on different aspects of teaching. This has already been discussed in the teacher identity section that a teacher identity is affected by the expectations people have of them (Reynolds, 1996). In some cases, the teachers mentioned that parents have expectations of teachers in term of their performance. However teachers did not elaborate much on how these expectations affected their teaching of SSIs. It can be presumed that since it is affecting their overall science teaching, teaching of SSIs is also included. For example, Pam revealed that parents' expectations influence their teaching as it changes their teaching goal in terms of what does they expect from parents' child.

"I'm going as a service provider. I'm going to work on what you're seeking from me. It depends if you [think your] child should get good marks, or is good in English, so I'll work accordingly. And these expectations come from parent teacher meetings." [Pam-I2-R34]

"As teachers you're not just responsible for marks. You're at much higher intellectual level than the child, and in most cases also from their parents, but (… .)It becomes difficult. Instead of taking something more from me they think I'm the service provider, who's supposed to talk and talk and get them good marks, nothing else. For me it can be more than that." [Pam-I2-R35]

6.9.4. Departmental conflicts

An implicit extra burden might also be created on teachers due to possibly bad relations between different teachers in the same department. In Rockford for instance, when a teaching method for a particular topic was fixed in the pre-academic year meeting, then the fellow teachers expect everyone to follow them accordingly. However, in case if a particular teacher, for instance Jane in Rockford wanted to teach a topic in more details or with alternative methods then she felt that the other teachers feel a problem with that - *"when I was teaching some topics too deeply to my students, some other teachers objected to it." [Jane-I2-R4]*. One possible reason, among others, for fellow teachers' reaction is the students' feedback as then

there is a possibility of students ranking Jane better than others due to her in-depth teaching. *"Then, students make comparisons, when they study with me and next year they study with someone else they compare, they just say that our previous teacher was really thorough we don't want this new one." [Jane-I2-R4].* Every teacher has their own teaching methods and teaching goals but when they compare their curriculum coverage to others then tend to feel under pressure and change their own teaching strategies. Jane disclosed this fact where she changed her teaching methods, just because she felt pressure because of other teachers' curriculum coverage and felt the time pressure.

> *"They're just interested in teaching those lessons [topics]. Yesterday, some teacher told me that she finished 4 lessons [topics] in 8 working days. She's not letting students discuss, maybe because they're not very confident, or they don't want that. This affects us too." [Jane-I1-R6]*

Although she did not agree with the teaching strategy of this other teacher, she feels affected by the implicit pressure such situations create. On the contrary, better collegial relationships with peers could lead to better teaching as then they discuss the depth each topic should be covered and an appropriate teaching method that students would appreciate and is beneficial for them.

> *"We are having collaboration like we discuss with each other once a week or once in two weeks that what is going on in the class. Suppose I am teaching a particular topic then we will discuss till what depth I am going to teach that topic and same for the other teacher." [Andy-I2-R3]*

The extra burden on teachers is also due to the organisation of various functions and activities for competitions, etc. Green Schools have to follow a regime of environment-related activities and projects that burden the teachers. Although the Green Schools initiative is directly related to SSIs, teachers feel that sometimes these activities are just an extra burden rather than adding to the understanding of the students.

> *"We (Teachers) are given deadlines for so many extra things. We are expected to have house (special clubs in school) duties (related to Green schools*

primarily); I've to guide students to all these extra useless things. Every month we're given some extra duties like decorating boards." [Jane-I1-R4]

"Whenever we have some extra work to do it does affect our teaching. Like some function [refers to the school level events, such as inter-school talent competitions] going on and as you need to be there. Sometimes I will not take the class because of the function. Some students as the mam please can [you] teach this topic again, unwillingly I have to say that I am sorry please come later, that I have to finish my work." [Annie-I1-R8]

6.10. Summary

In this chapter the factors that influence the teaching of SSIs have been elaborated. These factors range from very personal aspects such as teachers' beliefs to entirely external aspects such as the assessment system in schools. These factors are not just independent factors that individually impact the SSIs teaching proceedings; instead they are inter-related to each other in a way that they influence each other and sometimes have a combinational impact on the teaching of SSIs. To exemplify such inter-relations between the factors and highlight the key findings of this chapter, two cases are discussed further on related to the analysis of Jasmine's and Jane's interviews and observation sessions.

In case of Jasmine, the case is related to the Bio-Diesel project she undertook at Springdale School for a national level competition on SSIs-related research in education. For Jasmine her beliefs were the driving force to give a start to this particular project. Jasmine, as discussed previously, had a background as a researcher, and showed signs of multiple identities as a researcher and a teacher. This also had a significant impact on her beliefs. She believed in including research methods in her teaching to the best extent possible and making students aware of all aspects of SSIs as a part of her teacher identity. She talked about using different activities and methods to "infuse awareness, interest and sensitivity in [students]" [Jasmine-I1-R1]. When she came across the requirements of this competition, she prepared a sound plan of entering this competition with the Bio-Diesel project. She presented the plan to the school leaders, and as the school leadership in Springdale

is categorised as Democratic style leadership, they assured her with moral and financial support after a discussion on her plan. This shows the impact of support from school leadership on teacher's identity and teachers' authority. It is to be noted that the school leadership supported Jasmine a lot, but in many other schools teachers felt restrained. They had to grudgingly accept the decisions made by the leaders of the school (as discussed earlier in case of Andy and Jane), and felt they don't have much authority, which was not the case for Jasmine.

Thereafter, Jasmine required students that would participate with her in this competition. She initially believed that her students would be very enthusiastic about participating in the project. However, when she interviewed a set of "intelligent" students, they showed a high level of reluctance to participate in this project.

> *"(...) initially there were some very good students, good as in academically good students who said no mam we don't want to take part in it as this is something different from the academics and secondly it is not going to affect our grades. But now after seeing the outcomes they repent, initially they were reluctant because they thought that their studies will get affected, but now the scene is different." [Jasmine-I1-R13]*

This further exemplified her change in beliefs about students. She wasn't expecting a negative response from the high attaining students. Contrary to what she believed, students wanted to be involved only in activities that would help them attain good marks, or according to Jasmine would add "golden feather to their cap". This changed her perspective towards the selection criteria of students, and she then resorted to other students, and only picked students who were passionate and willing to go ahead with the project. Her beliefs about students were reformed during this particular incident. She admitted that from her past experiences in different schools, she believed that if students were provided with such an opportunity i.e. "going beyond the textbook" then students will be excited about it. During the course of the selection process, she realised that students in the senior section (16-17 age group) tend to become more focus towards attaining good marks.

However, when the project was a success and it won the competition, and received invites from research institutes in Germany and other countries, the same students who had rejected the project contacted Jasmine for being involved in next steps.

> *"It is more about the rat-race, the race to get good marks, get in competition, have the best of the careers but the basic understanding is still missing. It is not that everyone is same; some students are really different for example like our students were quite active in terms of green programs. (...) some students were part of the ECO club, they were actively working for it, but then when they realised that this is not helping them to get good marks or is not adding a golden feather in their cap, slowly and gradually they also joined the others."[Jasmine-I1-R15]*

This excerpt strongly reflects that though Jasmine was not an over-enthusiastic grade oriented teacher and believed in making the students scientifically literate, the response of students left her in retrospection over her beliefs and practices. Another striking feature of this case was that her beliefs about teaching of SSIs through different methods and activities were not shaken. She was motivated and showed extra impetus to work for the same. When asked about how this incident affected her perception about teaching of SSIs, she replied:

> *"It is a high time that they realise with their own logical reasoning that what they feel about certain topics that may affect them in future." [Jasmine-I1-R17]*

On the contrary in case of Jane, the case is related to her overall struggle to maintain her identity as a teacher in Rockford School. As evident from her teaching methods (special focus on discussion among students) discussed in previous chapter, she avidly believed in making students understand the importance of different aspects of SSIs. However, she felt the tension between the school ethos, practices and her own beliefs right from the starting of her job at Rockford (School leadership – Teachers' Beliefs). This also showcases the new teachers' identity as discussed by Reynolds (1996), as Jane was not confident enough to raise her opinion being the new teacher even if she disagreed to the opinions and practices of school

leaders. As discussed in the chapter, the school followed an 'Oligarchic' style of leadership, where only a certain clan of leaders or teachers had the decision making authority. No authority was conferred to her to make decisions or to contribute to the decision making for which even her own teaching was impacted. She felt a strong sense of strain because of the extensive set of activities (related to Green School initiative) that she were imposed upon her, and she did not relate to them at all. She felt more like an "art teacher" than a science teacher. She felt she was wasting her energies, and was eventually left with little time to cover curriculum and had to rush through it, which she did not like. This tension was not just limited to school leadership and her beliefs; she felt that tension even with other fellow teachers due to the different level of rigour with which Jane and they covered the curriculum. Consequently, due to the pressure of school leadership, fellow teachers, and an external time pressure created by new assessment system she had to modify her teaching methods.

Chapter 7 Conclusion

This chapter discusses the two Research Questions (RQs), addressed in this study, in light of the main findings presented in the previous chapters. Subsequently, the educational significance of this study is discussed, along with the possible implications of the results, with a specific focus on the curriculum development and the design of science teachers' development programmes. Finally, some possible directions for future research are discussed.

7.1. Research Questions

The research questions that guided the study were as follows:

Research Question 1 (RQ1):

(a) What teaching and learning methods and strategies are followed while teaching SSIs?

(b) What are the teachers' rationales for these methods and strategies?

Teaching methods are essential means of achieving certain ends, which in my study were related to students' acquisition of value, ethics, knowledge and awareness, related to SSIs. Pertaining to teachers' teaching goals, varied strategies might be employed with same teaching methods to meet the teaching goals. The choice of teaching methods and strategy is critical to an effective teaching of SSIs. RQ1 explored the teaching methods and the strategies teachers employ for teaching SSIs.

Research Question 2 (RQ2):

What are the factors (positive or negative) that influence the teaching of socio-scientific issues in the classroom?

In the face of the changing focus of science teaching practices from traditional canonical facts transfer to value-laden SSIs deliberations, it is necessary to examine the factors that facilitate or hinder the SSIs teaching. A number of

researchers have already pursued this research objective in various contexts, e.g., (Anagün and Özden, 2010, Lee et al., 2006, Ryder and Banner, 2013), yet RQ2 aimed to address this research objective to bridge an important gap of empirical studies on SSIs in the Indian context.

7.2. Key contributions of the research study

In-depth studies exploring teachers' perspectives on the teaching of SSIs are sparse, in particular in the Indian context. This exploratory study contributes to the existing knowledge by providing valuable insights into the teachers' perspective on SSIs teaching in the Indian context. Specifically, the study investigates the methods and strategies employed by teachers for teaching SSIs, their rationale for the selecting a particular method or strategy, and teachers' perspective on the personal and contextual factors that facilitate or hinder their teaching of SSIs.

The findings from RQ1 in this study suggest that **discussion and lecture method are the two most prevalent methods for the teaching of SSIs in the contexts studied**. Within discussions, four different discussion patterns have been delineated in my study (discussed in Section 7.3.1. in more detail). This could prove beneficial for both research and practice (SSIs teaching) as each discussion pattern provides information on the teaching goal it addresses and the context in which it is applicable. Between lecture method and discussions, lecture method was largely considered as the go-to method in most situations by teachers, and for a few of them it was the main method used for teaching SSIs. Teachers preferred using lectures whenever they wished to maintain the decorum of the classrooms, or they faced any pressure or time constraint, such as a pressure to cover curriculum. Discussions were also very frequently used by a majority of teachers. However, unlike the lecture method it was not the go-to method in the pressure situations. Teachers stopped discussions (or, in fact any other interactive method like debates) for teaching SSIs whenever the examinations were approaching. This action of teachers can be construed as a premise that the teachers, except for the teachers that have strong personal beliefs in favour of the SSIs teaching, considered discussion or debate as more of an extra-curricular activity.

The findings from RQ2 in this study suggest **that the school leadership and teachers' beliefs are the two most influential factors for SSIs teaching** in Indian context. The factors, however seldom had an impact in isolation from other factors, i.e. the influencing factors are interrelated to each other and any impact on SSIs teaching is usually due to multiple factors. My study provides a preliminary insight into the individual factors and the interrelation between them.

School leadership, one of the most influential factors, is closely related to the other factors, such as teachers' authority in the classroom, departmental conflicts, and the motivation of teachers for teaching SSIs. The classification of leadership styles (*monocratic*, *democratic*, and *oligarchic)* delineated in this study is one of the most significant contributions to the existing literature, as there is limited previous literature on leadership styles as they relate to SSI teaching. These leadership styles and their impact on SSIs teaching can be instrumental in future research not only in this area, but also beyond the confines of just SSIs research.

Teachers' beliefs that influence the teaching of SSIs were found to be closely related to their personal and professional backgrounds, and their identity. Based on the teachers' beliefs about SSIs teaching and their actions in this context, a profiling of teachers was done based on the classification suggested by Sadler et al. (2006). The teacher profiles in my study go beyond the classification of Sadler et al. (2006), suggesting a need for an extension to that end. Further, the impact of the teachers' beliefs on the epistemic and deontic authority of the school leaders was witnessed in my study, the situations where the teachers perceived their leaders to be lacking the epistemic authority led to a feeling of discontentment in teachers.

The main findings of the research questions from my study are discussed further in this chapter, and the significant findings have been highlighted in bold.

7.3. RQ1 findings: Methods and strategies for teaching SSIs

The most dominant teaching methods identified in my study for teaching SSIs are discussions, and lecture methods. These two methods are more dominant than others due to their prevalent use of these methods for teaching SSIs, and the frequency by which they were mentioned by the teachers in their interviews.

Another teaching method that needs to be mentioned here is the debate. Although the teachers, did not use debates as frequently (as discussions and lecture method) nonetheless some interesting insights were found from the teachers that use debates as a teaching method. The findings from these three teaching methods have been further discussed, followed by some other general key findings from RQ1 analysis.

7.3.1. Discussions

Importance of discussion teaching method. The importance of discussions for teaching science has been previously highlighted by researchers, such as Shemwell and Furtak (2010). Similar views were witnessed regarding discussions as a teaching method in my study for teaching SSIs. The teachers considered discussions to be an effective method for active-participation of students. In contrast to these findings, Lemke (1990) and Driver et al. (2000) highlighted the lack of the actual application of discussions in science classroom teaching, despite their advantages. This was not the case in my study as teachers did conduct discussions while teaching SSIs. However, as mentioned in Section 7.2, they stopped discussions or other interactive activities, such as debates when the examinations were close or the pressure to cover curriculum was there. This treatment of discussions as a teaching method, hints towards the consideration of discussions or debates by teachers as more of extra-curricular activities.

Discussion Patterns. Four different patterns of discussions emerged from the data analysis of the teaching methods. Table 7.1 provides an overview of these discussion patterns. More details and the teachers' rationale for teaching using these patterns have been discussed in Section 5.2. On comparing these discussion patterns to the similar existing frameworks, such as the one discussed in Table 2.2, an interesting finding was that none of the teachers in my study expressed thoughts about discussion as a skill that would require practice. Further, the discussion models framework in Table 2.2, presents a developmental progression of discussions from teacher-initiated discussions to more independent and higher-level discussions among students. In contrast to this, the discussion patterns in Table 7.1 are not a part of any particular framework. These discussion patterns were the

personal choices of the individual teachers, based on their teaching rationales and pedagogical skills, and do not assume any particular sequence.

Table 7.1. Characteristics of Discussion Patterns

Form of Discussion	Characteristics

Open Discussion	• Initiated by teacher
	• Aim:
	  ○ Increase the inquisitiveness in students
	  ○ Assess previous knowledge of students
	  ○ Collect different perspectives
	• Timing: Before introducing a chapter / topic
	• Teacher's Role: To provide "cues"
	• Not interrupted by teacher at any point in terms of exchange of ideas by students

Funnelled Discussion	• Initiated by teacher
	• Pre-discussion: Brief introduction of a topic by the teacher to narrow down the scope of the discussion
	• Aim:
	  ○ Engage students with the content of the chapter
	  ○ Assess previous knowledge of students
	  ○ Cover certain important points related to the topic
	• Timing: Before introducing a chapter / topic
	• Teacher's role: Channelize the discussion

Unplanned Discussion	• Spontaneously triggered • Aim: ○ Clarify students' doubts • Timing: During the teaching of a topic – triggered by students' queries • Teacher's Role: Facilitator and moderator • Frequently the course of discussion goes on a tangent, requires pedagogical skills and confidence in teacher to handle such a discussion

Pre-Planned Discussion	• Initiated by teacher
	• Pre-discussion: Entire topic/chapter is covered by the teacher
	• Aim:
	  ○ Foster critical thinking in students
	  ○ Gather multiple-perspectives from students
	  ○ Help students relate the scientific content learned in the chapter to the real-life
	• Timing: After completing a chapter / topic
	• Teacher's role: Plan the discussion and moderator

	• Mostly carried out by the students as they are well versed with the scientific concepts and since the discussion is pre-planned students have time to gather information for discussion

Relation of discussion patterns to the existing research. Mortimer and Scott (2003) developed a framework for analysing the discursive interactions of science classrooms, which relates to the discussion patterns discussed in Table 7.1 and some other teaching methods discerned in my study. The *authoritative/interactive class* in Mortimer and Scott (2003) framework is similar to the characteristics of funnelled discussions observed in my study, except that the teachers in my study did not stringently discard any viewpoints of students that (as per teachers) were not targeted at the 'right message' as was the case described in the *authoritative/interactive class*. The *dialogic/interactive class* matches very closely related to the open discussions in my study. The *authoritative/non-interactive class* matches to the explanatory lecture method discussed further in this chapter, as in both the cases, teachers preferred one-way communication in the classroom. The *dialogic/non-interactive class* partially maps to the characteristics of the interactive lecture method in my study. The dialogic/non-interactive class refers to the teaching where the teacher discusses multiple-perspectives but non-interactively. In my study, although the student-student interaction was limited in the interactive lecture method, but unlike non-interactive nature of dialogic/non-interactive class, the teacher to individual student's reaction was present. However, in both *dialogic/non-interactive class* and interactive lecture method the control was always with the teacher and focus was on presenting the multiple perspectives of a topic.

Fisher and Larkin (2008) conducted a survey which suggests that teachers continue to be more concerned with keeping discussions polite and orderly than with exploiting its learning potential. This relates to our finding that some of the teachers were concerned about the decorum of classroom during interactive activities and even stopped the discussions when it seemed like getting out of hand. This was particularly true for the unplanned discussions that were not initiated by the teachers. Even if the need arose for an unplanned discussion, they tried to keep it to a bare minimum.

Duration of discussions. Another finding when considering interactive teaching strategies made in my study is related to the duration of discussions. Only a few teachers that strongly believed in the teaching of SSIs conducted discussions or debates that lasted for more than half a period (20 minutes). Others wrapped up the discussions at the first possible opportunity, which was similar to the findings of Mercer et al. (2009) that the time spent by the teachers in discussions is very short and teachers tend to wrap up the discussions very quickly.

7.3.2. Lecture Method

The lecture method is generally used in traditional science teaching. In this study, almost all the teachers resorted to explanatory lecture method when they had to teach scientific content related to SSIs, or considered as a go-to method when they were facing any time constraints or pressures. Andy, a teacher that did not believe in the inclusion of morals and ethics in science curriculum majorly followed only this method for instruction. The explanatory lecture method, a variation of lecture method, was used by teachers to explain the subject content to students (without much interaction) when they taught content, they believed was important from the examination perspective. At other instances, teachers used another variation of lecture method, i.e., interactive lecture method where they asked students about their experiences about specific issues while teaching subject content. Andy was the only teacher, who never resorted to much interaction as he felt that it might lead to indiscipline in his class. Teachers showing similar behaviour were studied by Barrett and Nieswandt (2010), which similar to Andy contained any discussion or interaction in the class to a bare minimum. However, the rationale behind not allowing any interaction was different in both studies, teachers in (Barrett and Nieswandt's) study did so as they felt they might not remain objective while doing so and they believed in value-neutral science education, and not because of discipline issues as with Andy.

7.3.3. Debates

Forms of debate. Two forms of debates (as teaching method), adversarial and multiple-perspective debates, were witnessed in this study. The two forms differed in the number of viewpoints being contended in a debate. The adversarial

debate dichotomised the discussion on SSIs, with students having to choose one of the two viewpoints being contended. The multiple-perspective debate, on the other hand, placed no such restriction on the number of viewpoints. The analysis of interview and observation data has shown that a significant majority of teachers that conducted debates, preferred adversarial debates over multiple-perspective debates.

Teachers' role in debates. Apart from the classification of debates by number of viewpoints presented above, another distinctive characteristic of debates witnessed in my study was the teachers' role. In some debates (largely adversarial) the teachers conducted the debates themselves, and in other instances (largely multiple-perspective) shared the responsibility of conducting debates with humanities teachers.

When conducting the adversarial debates by themselves, teachers tried to ensure that students remained within the confines of the dichotomised viewpoints and restrained any viewpoints beyond the two viewpoints being contended. In fact, in some instances teachers even assigned a given viewpoint to the students and asked them to defend it, instead of letting the students defend their own personal viewpoint in a debate. This insight raises an important question for further research: do the teachers consider the dichotomisation of viewpoints as an inherent trait of debates, or they believe that SSIs can only have right or wrong (dichotomised) answers. If the latter is the case, then this would have ramifications beyond the confines of my research and implications on the teacher development programmes (see Section 7.5).

When conducting multiple-perspective debates, the majority of teachers preferred conducting them in collaboration with the humanities teachers. They believed that their role as a science teacher should be limited to providing relevant scientific content to students, and the humanities teachers are better skilled to conduct debates. This concurs with the findings of Day and Bryce (2011), Levinson et al. (2001), Lewis and Leach (2006) where they discussed the situations where the expertise of humanities teachers in conducting debates with multiple perspectives

was sought, where science teachers lacked the required expertise other than the subject knowledge. The collaboration between science and humanities teachers for conducting debates related to SSIs, was also encountered in the research by Harris and Ratcliffe (2005), where the humanities and science teachers collaborated on a specific day ('collapsed day') to conduct discussions and debates to support SSIs learning experiences. The collaboration, however, differed from the ones witnessed in my study as the 'collapsed day' was a one-off event at the schools that lasted for just a day, unlike the observations from my study where the teachers formed relatively longer collaborations that occurred more frequently.

Teachers did not consider debate as a skill. Finally, a finding similar to that in the discussions was that the teachers did not reflect upon debates as a skill that should be developed in students. As indicated by Lazarou (2009), debating is an important skill that needs to be developed in students when aiming for scientific literacy. Teachers' lack of consideration towards discussions or debates as a skill that needs to be developed in students can be construed as a premise that the interactive teaching methods are considered as extra-curricular activities by the teachers and the curriculum designers, as discussions and debates are not a part of the assessment system of science teaching. This observation has been mentioned in Section 7.5, as an implication on teacher development programmes.

7.3.4. Other major findings from RQ1

Teachers' rationale for selecting methods and strategies were closely related to their beliefs about the teaching of SSIs: The selection of teaching methods by the teachers was closely related to their rationales. For instance, the teachers that wanted to foster critical thinking in students wanted them to understand the multiple-perspectives of SSIs selected teaching methods that would meet these rationales, such as pre-planned discussions or debates with students.

The teachers' rationales for selecting these teaching methods and strategies were related to their beliefs towards the teaching of SSIs. The teachers that strongly believed in the teaching of SSIs were observed to have a higher tendency to select teaching methods and strategies that were interactive, as these teachers were keen to

discuss the important aspects of SSIs with students and sensitise them towards these issues. In contrast, the teachers that did not believe that teaching ethics is a part of science, concentrated on teaching methods that were non-interactive and did not provide any opportunity for discussion or interpretation (e.g., explanatory lecture method). The focus of such teachers was to help students grasp the canonical facts so that they can reproduce their factual knowledge in exams and secure good marks. This concurs with the findings of Osborne et al. (2002) that science teachers tend to resort to teaching methods that are autocratic, closed and authoritative in nature. They believe that science is a subject of well-established facts, which is not open to any question or interpretation.

None of the teachers in my study selected the teaching methods or strategies that would require them to relinquish the control of the classroom. In all the teaching methods and strategies discerned in my study for teaching SSIs, the major control of the classroom during discourse was with the teacher. None of the teachers utilised teaching methods, such as small group discussions, that would relinquish much more control to the students. A possible reason for this was that the maintenance of decorum during the teaching was an important concern for teachers. This finding concurs with the findings of Day et al. (2006) that science teachers lack the confidence in conducting discussions or utilising the teaching methods that would require them to relinquish control to students, as they fear losing the control of discipline. Along with maintaining the control of decorum, the teachers wanted to maintain the control of the learning outcomes of students. (Bosser et al., 2015, Day and Bryce, 2011, McIlmoyle, 2010) found that teachers at all times want to remain in a state where they are ahead of the students in terms of content knowledge. Relinquishing the control to students could lead to a situation outside the comfort or content knowledge zone of the teacher, which is not desired by them. Hence, Day et al. (2006) noticed that science teachers feel that humanities teachers are more skilled in such situations. Humanities teachers are less fearful to relinquish control of the discourse to students; as for them relinquishing the control of the classroom decorum is separate from the control of the discourse. This was also found in my study that a few teachers considered humanities teachers to be more skilled for conducting discussions and debates, as they are more skilled to maintain the decorum of the classroom and conduct discussions.

Teachers find it difficult to grasp the true multiple-perspectives nature of SSIs. As discussed previously in my findings chapters, the teachers primarily dichotomised the SSIs and the debates around SSIs. The majority of the teachers that conducted debates conducted adversarial debates highlighting the problem in understanding the multiple-perspectives of SSIs. Even the teachers (except, Victoria) that did conduct multiple-perspectives debates had a 'right message' in the mind, which would be the concluding point of the debate. Such a misconception about the teaching of SSIs, was also encountered by Lee et al. (2006) as they mentioned that *"right-wrong dichotomy that seems to have pushed many participants in this study away from addressing SSI"* (p. 113). This findings provides a crucial characterization of teachers' beliefs or in fact misbeliefs about SSIs, which needs to be addressed in order to improve the current state of the practice of SSIs teaching.

7.4. RQ2 findings: Factors influencing the teaching of SSIs

The findings of RQ2 discussed in Chapter 6, suggest that two key factors that influence the teaching of SSIs in the context of this study are school leadership and teachers' beliefs. School leadership and teachers' beliefs are closely related to many other factors that influence the SSIs teaching, and more often than not are the actual underlying reason for the impact on the teaching. The close interrelation of factors is another phenomenon that was witnessed in Chapter 6, where an impact on SSIs can be traced back to an interrelation of multiple factors rather than a single factor in isolation. The key findings related to school leadership, teachers' beliefs, and other factors have been further discussed in this section.

7.4.1. Influence of school leadership

Despite a significant level of variation in the characteristics of the schools chosen in this study, the influence of school leadership on the teaching of SSIs was one of the most consistent factors delineated during the course of this study. The school leadership's perspective towards SSIs, the leadership styles, the way school leaders exercise their deontic and epistemic authority and their support to teachers

were the key aspects, related to school leadership, influencing the teaching of SSIs. The key findings from the influence of these aspects are discussed below.

The perspective of school leadership towards SSIs is the key. Three out of five schools covered in this study are categorised as *Green Schools*. As indicated by the data in the results chapter, the *Green Schools* were significantly inclined towards teaching environment-related SSIs in comparison to the non-Green Schools (schools that did not participate in the Green School programme). A general trend witnessed across all the Green Schools was a high level of efforts and commitment of school leadership towards maintaining a spot in the prestigious national Green Schools list. The school leadership, in these schools, was more emphatic in inculcating a culture of environment-related SSIs teaching in their schools, which is similar to the Green Schools in other nations facing major environment-related problems, such as China (Wang, 2009, Zeng et al., 2009), and other places such as, Maryland in the USA (Ghent et al., 2014). On the other hand, two schools that were not Green Schools did not show much commitment towards SSIs teaching, and the coverage of SSIs in science teaching was primarily dependent on the beliefs of the individual science teachers. At times, the lack of backing from the school leadership, in these schools, impeded the SSIs teaching (examples are provided in Section 6.4). Hence, the issues and teaching practices that are consistent with the goals of school leadership are more likely to be backed by the school leadership.

The agreement between the school leadership goals and teachers' perspectives facilitates / hinders the SSIs teaching. The school leadership style had a considerable influence on teachers' morale and motivation for teaching SSIs, and their job satisfaction in general. This resonates with the findings of (Evans, 1998, Kelley et al., 2005, Ubben et al., 2001) that school leadership is one of the most influential factors that impacts teachers' morale and job satisfaction. Foremost, a level of agreement between science teachers and school leadership played a significant role in the teaching of SSIs. The lack of agreement between teachers and leaders' views about teaching goals, school culture or teaching methods compromised the SSIs teaching. The extent of impact by the lack of agreement between teachers' perspectives and school leaders on SSIs teaching was significant. It hindered the SSIs teaching even for the teachers that espoused the teaching of SSIs. This

was particularly apparent in monocratic leadership and for the teachers that lacked freedom in oligarchic settings. On the other hand, the agreement between the school leaders and teachers, or the freedom and decision-making authority to teachers resulted in positive-attitude towards the teaching of SSIs (in democratic leadership and teachers that were also leaders in oligarchic settings) (Varuhas et al., 2003). Evans (2001) noted a similar phenomenon, where in teachers' "*negative attitudes are associated with contexts where leadership features prominently, positive attitudes are associated with contexts where there is much more leader-independence*" (Evans, 2001) (p. 300). The negative attitude resulted in either a submissive or an indifferent attitude towards the school leadership objectives. The situations where the teachers believed the school leaders were unfair led to the dissatisfaction or the negative attitude of teachers, which has also been previously witnessed by Manik (2010) in the context of Indian teachers.

School leadership's support to the teachers can impact SSIs teaching. The school leaders' support and positive reinforcement to the teachers is an important aspect for teachers' morale and self-efficacy beliefs. The interview data has shown that the lack of support from the leader predominantly led to an environment of distrust between teachers and leaders, even grudges in the teachers. This hampered the morale and self-efficacy beliefs of teachers, and consequently impacted the initiatives teacher took for teaching SSIs. The support from the leader is required both at the personal-level and in terms of resources. This resonates with the findings of Mulford (2003) that positive reception from leaders to teachers can infuse a sense of ownership in teachers and encourages them to continue their efforts in teaching. McMinn et al. (2015) shared similar views, about the support from the school leadership. The teachers' in their study reported on several factors that impeded the implementation of the teaching ideas they believed in. Most of the factors were related to the lack of resources and support from the school leadership. McMinn et al. (2015) asserted the importance of school leadership's role in overcoming these impeding factors, and most importantly reducing the discrepancies between the espoused beliefs and practices of teachers in science education.

7.4.1.1. The style and authority of school leadership

One of the key contributions to knowledge of this thesis is the classification of school leadership styles and its impact on the teaching of SSIs. The three leadership styles, i.e., *monocratic*, *democratic*, and *oligarchic*, discussed in detail in Table 6.2, were primarily classified based on the distribution level of authority for decision-making. The leadership styles that encourage the participation of teachers in the decision-making process lead to an environment of trust and belongingness for the teachers. This includes all the teachers in democratic leadership and the teachers involved in decision-making in oligarchic settings. Teachers' interviews revealed that the situations where decisions are imposed upon them by making decisions that impact their teaching might lead to negative emotions and a feeling of not belonging. These findings are coherent with the findings pertaining leadership styles discerned by (Burns, 1978, Lewin et al., 1939, Likert, 1967) which have been compared below to the leadership styles discerned in my study.

How the leadership styles relate to the leadership styles in the literature. Likert (1967) suggested four types of school leadership styles - exploitative authoritative, benevolent authoritative, consultative and participative. The exploitative authoritative and benevolent authoritative styles map to the characteristics of the monocratic style in my study. The main difference between the exploitative and benevolent leadership is the reward and punishment given to the teachers by leaders. In my study, the teachers under monocratic style did not reflect upon any such idea of rewards/punishments. The participative leadership style of Likert (1967) maps to the democratic style in my study, also to some extent to the consultative style where leaders made a conscious effort to consider the ideas of teachers for decision-making. However, the final authority of decision-making lay with a single leader in the consultative style, unlike democratic style where the decisions were made collectively. None of the leadership styles by Likert (1967) match the characteristics of the oligarchic style in my study, where the decision-making power was distributed among only a few chosen leaders and the non-leaders (teachers) were not consulted.

Lewin et al. (1939) discerned three types of school leadership, namely, autocratic/authoritarian, democratic/participative, and laissez-faire/passive. The autocratic/authoritarian leadership style matches to the monocratic leadership style, and democratic/participative style matches to the democratic style in my study. The oligarchic style of leadership does not match to any of the three leadership styles by (Lewin et al., 1939). Additionally, none of the teachers in my study referred to their leaders characteristics similar to that of laissez-faire/passive style, which refers to a leader that allows the teachers absolute freedom for decision-making without participating himself/herself in the decision-making process.

Burns (1978) consolidated the leadership profiles from Lewin et al. (1939) and Likert (1967) into two profiles, i.e., transformational leadership and transactional leadership. Transformational leadership style encompasses the participative leadership style mentioned above and the democratic style in my study. It refers to the leaders that show an increasing interest in the overall growth and performance of teachers, and believe in a shared vision of goals and an environment of trust to achieve these goals (Bass, 1985, Burns, 1978, Carlson, 1996). Transactional leadership encompasses the Lewin et al.'s (1939) autocratic and Likert's both variations of authoritative style and is similar to the monocratic style in my study. Transactional leadership focuses on the reciprocal exchange of duties and rewards between the principal (primary leader in a school) and the teachers for achieving certain working goals, whereas no explicit mention of the exchange of duties and rewards was mentioned in my study. Monocratic and democratic styles of leadership have been widely studied in the previous research. However, no direct match of oligarchic leadership style has been witnessed in any of the studies.

Teachers' perceptions of the epistemic authority of leaders can impact teachers' outlook. Another salient feature of school leadership's influence on the attitude of teachers towards SSIs teaching was the teachers' perception of the epistemic (knowledge-based) authority (Tirri and Puolimatka, 2000) of the school leaders. The epistemic authority refers to the authority of a person in terms of knowledge. In certain cases, teachers' discontentment towards the imposition of science-teaching decisions on them by leaders was accompanied by a sense of confidence in the school leader's decision making. The juxtaposition of teacher's

responses was explained by the epistemic authority exercised by the school leader. The epistemic authority of the leader positively impacted the commitment of teachers towards the teaching of SSIs, despite early discontentment from the lack of freedom and teachers' own deontic (position-based) authority. A few teachers reflected on their discontentment turning into negative emotions of frustration and low job satisfaction, when the teachers had no deontic authority in the decision-making and the epistemic authority of the leaders making decisions for them was questionable, according to the teachers.

7.4.2. Teachers' Beliefs and Identity

The school leadership styles, school leadership goals, how teachers' work together, the local community values, and the trust between school leadership and teachers are the key ingredients that collectively form a school's culture. From teachers' perspective, school culture has a significant impact on their beliefs and identities (Wallace and Kang, 2004, Warren, 2002). Another set of influencing factors that had a significant impact in the teaching of SSIs were related to the personal aspects of a teacher, i.e., their beliefs and their identity. Jenkins (1992) reported that in reality science teachers are not really "passionate" about incorporating SSI into their classes. Many science teachers experience problems such as insufficient knowledge of social ramifications, lack of teaching strategies, limited resources, and inflexibility of curriculum (Lee et al., 2006). Also, some teachers feel a tension between the teaching of controversial issues and the traditional value-free science curricula (Cross and Price, 1996). Only a very few teachers reflected on any such problems with SSIs teaching. Some teachers were in fact "passionate" about the teaching of SSIs. The findings related to teachers' beliefs, relation to actions and the tensions faced by teachers are discussed below.

7.4.2.1. Teachers' perspectives on SSIs

Teachers are the main implementers of any curriculum and play an important role in the curriculum reforms (Lee et al., 2006, Topcu et al., 2010). They have the ultimate control over what is taught in the classrooms. Any reform effort aimed at introducing value-laden science education is unlikely to be effective without considering teachers' perspectives (Barrett and Nieswandt, 2010). An

important research gap remains in understanding the teachers' perspective on SSIs and their roles in science education. Especially in the Indian context, there's an acute lack of empirical evidence on teachers' perspectives on SSIs.

As described earlier in Section 2.1, perspectives are a combinations of beliefs, intentions, interpretations and actions. Thus, in order to explore teachers' perspectives, it is important to take in account of their beliefs. While examining teachers' perspective on SSIs, a pervasive issue that I came across my entire study was that not all the teachers were able to articulate their beliefs about SSIs, thereby making the examination of teachers' perspectives on SSIs difficult. This difficulty, as suggested by Lee and Witz (2009) primarily arises due to the deep-rooted or the tacit nature of beliefs (Lee et al., 2006). Furthermore, even when the teachers expressed their perspectives on SSIs they did it interchangeably with their perspectives on the teaching of SSIs. The two perspectives, as asserted by Lazarowitz and Bloch (2005) and Witz and Lee (2009) are inextricably entangled. This phenomenon can be exemplified by the experiences of Katie in my study who narrated a (personal) incident during her pregnancy and how that particular incident had a significant (positive) impact on her current teaching practices, in particular for the teaching of genetics related SSIs. Here, she expressed her beliefs on the teaching of SSIs and traced them back to an incidence of emotional significance in her past. As an interviewer, to me, these beliefs of hers seemed more closely related to her beliefs about SSIs, but that was the result of only my interpretations. On an in-depth analysis of this teacher's interview transcript, I could extrapolate the links between the personal incidence and the views on SSIs and the impact of it on her teaching of SSIs, although such links were never mentioned explicitly. This extrapolation seemed to be natural in light of the concurrence between teachers' beliefs and her in-classroom actions. However, making such extrapolations or interpretations is not always possible for a researcher, as found by Lee and Witz (2009), the teachers' beliefs on SSIs and their actions may not always be consistent. A noteworthy point here is that teachers did not mention their views on SSIs explicitly, and although as a researcher I could make some interpretations about teachers' interviews, these interpretations could be challenged. Additionally, an interesting observation here is that such interpretations could only be extrapolated from the teachers' narratives of their biography where they showed

glimpses into the origination and formulation of their current beliefs, such as some particular incidences, their treatment as a student, and previous professional experiences. Not all the teachers discuss their biography or did it in such detail that any inferences could be made. Hence, after an analysis of my data, it was clear that the evidence for teachers' perspectives that was explicitly deducible from the data was primarily on the teaching of SSIs and was actually an underlying personal factor that impacted their practice of SSIs teaching. However, as discussed in Section 6.2.5. Teachers' beliefs are the most important constituent of their perspectives that influence the teaching of SSIs. The main highlights of the impact of teachers' beliefs have been discussed next.

7.4.2.2. Teachers' Beliefs

The analysis and presentation of teachers' reflections in this study have shown that teachers' beliefs were a major factor that were instrumental in teachers' perspective towards SSIs teaching. The scope of beliefs was not restricted to just educational beliefs of a teacher and instead spanned more generic beliefs. Considering generic beliefs of teachers is imperative as SSIs deal with a wide range of aspects, including social, morals, values and ethics. Along with understanding the teachers' beliefs it is also important to understand the process of beliefs' formulation. Without synchrony with the underlying beliefs of teachers and the factors responsible for their formulation, it might be difficult to achieve the ultimate goals of introducing SSIs inscience.

To examine teachers' beliefs about SSIs, the first step was to capture teachers' beliefs about the teaching of SSIs. Out of the few teachers that could articulate their beliefs in this study, the possible sources for the formulation of their beliefs were related to the upbringing of teachers, experiences of teachers as a student, incidences of emotional importance, past careers, and educational backgrounds. This is in agreement with the description of teachers' beliefs (Nespor, 1987), where he describes beliefs as the psychological constructs formulated from the personal, emotional and episodic experiences. An interesting observation in data analysis was that the teachers that displayed strong views (for or against) about the

teaching of SSIs were more easily able to articulate their beliefs and to some extent the sources of their formation.

7.4.2.3. Relation between teachers' beliefs and actions

The primary beliefs that influenced the teaching of SSIs were related to the beliefs of teachers about goals for science education, morals and ethics, science practice (science as a value-laden subject), and students. Teachers' beliefs had an impact on their teaching, including their choice of teaching methods, commitment towards the teaching of SSIs, their emphasis on a particular topic, or teaching actions in general. A bidirectional relation between teachers' beliefs and actions was apparent for many teachers in this study. The beliefs regarding SSIs instruction guided the actions of teachers in the classroom, and their actions in turn strengthened their beliefs over a period. For example, Andy believed against the inclusion of SSIs in science education and should focus on the transfer of reproducible canonical facts. His teaching methods, influenced by his beliefs, produced success as he was considered as one of the teachers whose students secured high grades in average. These actions and their success strengthened his beliefs that science is a value-free subject. This relation between teachers' beliefs and actions has been independently noted by many other researchers in the past (Bybee, 1995, Clark and Peterson, 1986, Pajares, 1992, Scott et al., 1994, Wallace and Kang, 2004) .

Matching of the teachers' profiles. In the literature review chapter, I presented a few studies (Anagün and Özden, 2010, Barrett and Nieswandt, 2010, Gardner and Jones, 2011, Mitchener and Anderson, 1989, Sadler et al., 2006) where researchers attempted to categorise teachers into profiles based on the interplay of their perspectives and practice, for e.g., the profiles described in Table2.1(Table on profiles by Sadler et al. (2006)). In this study, 12 out of 14 teachers matched to the profiles described in Table2.1. However, there were two interesting cases where teachers did not fit any one of the profiles (discussed below). Three out of total 14 teachers (Jasmine, Katie, and Pam) belonged to profile-A, four teachers (Daisy, Jane, Nancy, and Paula) befitted profile-B, three teachers (Annie, Simi, and Kady) can be classified under profile-C, one teacher (Andy) matched profile-D characteristics, and

one teacher (Victoria) shared characteristics with profile-E teachers, as she believed that moral and ethics should be a part of overall education, not just science education. Two teachers, namely Sofia and Dolly, did not fit into the exact characterisation of any one profile. Sofia, similar to profile-C characteristics, was unsure about the inclusion of SSIs except the issues related to the environment. Due to her past job in state pollution board, she felt responsible for making students aware of all the aspects related to environmental issues and covered them in practice like profile-A teachers. This disparity of profile characters can be attributed to the teacher's personalisation of teaching goals. Dolly, on the other hand, did not talk much about her own beliefs and instead represented her principal's beliefs and agreed to her principal's conception of teaching actions. Although she was presenting SSIs in practice, it is difficult to categorise her into a single profile. This was a unique case as teacher's beliefs were completely subsumed by a school leader's beliefs and were so extensively impacted by school culture. To conclude the comparison to typical teacher profiles (profiles A-E) in similar settings, a majority of teachers did comply to or fit into the given profiles. However, this study does indicate towards possible deviations from the typical teacher profiles. Hence, this concludes that although a majority of the teachers' profiles matched to the profiles in the literature but the teachers cannot be stereotyped to just these profiles.

7.4.2.4. Teachers' Identity

The notion of identity is captured by Gee (2000) as a "kind of person" within a particular context, which means multiple forms of identities are possible under different contexts in which a person operates. As discussed previously in Section 6.3, teachers' identity is related to the notion of 'institutional identity' by Gee (2000), which is the answer to teachers' perspective of "who I am" (p.102) and the role and duties associated with this perspective. For example, a range of identities assumed by teachers was witnessed in my study, such as, 'researcher', 'statistician', 'environmentalist' and a 'science teacher'. An interesting observation during my entire study was that the teachers' identity or what they saw themselves as being had a close connection to their beliefs, and their identity and beliefs in turn had a profound impact on their teaching actions. The different identities, i.e., 'researcher' or 'environmentalist', were reflective in teachers' choice of activities or other teaching actions and the beliefs they espoused. Similar observations were previously

made by Goodnough (2010) and Helms (1998), that the teachers' identity emanate from their beliefs, or the concept of identity is intertwined with the beliefs of a person, and the beliefs in turn guide their actions (Akkerman and Meijer, 2011). Furthermore, teachers' identities as witnessed in our study are not static. They change with the change with the change in the surroundings of a teacher. For instance, the professional identity of Sofia in my study emerged from that of a 'statistician' to a 'teacher' on change of careers from environmental statistician to a science teacher. This finding supports the characterisation of identity by Coldron and Smith (1999), that identity is a dynamic and emergent concept that changes with the teachers' surroundings and with the change in school culture (Mockler, 2011, Reynolds, 1996). However, despite the change in the professional identities certain core beliefs of teachers manifest themselves consistently across the identities (Kelchtermans, 2005), e.g., the beliefs about the importance of environmental SSIs were maintained across both 'statistician' and 'teacher' identity.

A significant finding, in this study, related to the impact of teachers' identity on SSIs teaching, is the tensions related to the subject specific teacher identity. A few teachers reported on the identity tensions whenever what teachers perceived as a professional identity of a 'science teacher' was not aligned with what was expected from them by the school leadership. In this study, such tensions were encountered with three teachers, where teachers were impelled to conduct SSIs related activities by school leadership. Teachers experienced identity tensions, as they deemed these directives from school leadership as fruitless for students, or as a threat to their professional identity as a science teacher (more details in Section 6.3). These tensions resulted in teachers feeling detached from the school values, practices, and goals. As a consequence of continuous such tensions and detachment from the school values and goals, in this study, the teachers felt stressed and frustrated in their jobs. This finding directly relates to the findings of Ryder and Banner (2013), who encountered similar tensions for a science teacher in their study on the application of SSIs-related reforms. This further relates to the findings of Beijaard (1995), MacLure (1993) that noted down the possible repercussions from identity-related tensions, i.e., extreme frustration in teachers, e.g., thoughts of resigning and early retirement. Another implication of subject-specific teacher identity tensions was discussed by Mitchener and Anderson (1989), where tension arises when a new or a

change in professional identity is expected from a teacher (for, e.g., on introduction of curriculum reforms), it results in personalization of the new goals by teachers, by blending the goals of existing and expected identities together.

7.4.2.5. Teachers' Identity and personalisation of teaching goals

The conception of teachers' identity as a 'science teacher' differed to a significant extent for each teacher in this study. Teachers related their professional identity to various roles, such as that of a facilitator, explorer, researcher, disciplinarian, dispenser of knowledge, a role model. These roles have been discussed in detail in chapter 5. Based on the conception of each teacher's identity they had also personalised their teaching goals. These teaching goals formed the basis or rationales for their choice of teaching methods in classroom practice. These rationales (discerned in interviews), included among others, foster critical thinking in students, prepare students for real life situations, awareness in students, develop evidence-based critical thinking, prepare students for exams, develop interest in a topic, avoid indiscipline in classroom while teaching, and discuss topics as fillers to rejuvenate the interest of students. This personalisation of teaching goals relates to the findings of (Barrett and Nieswandt, 2010, Lee and Witz, 2009, Reis and Galvão, 2004a), where they discussed the personalisation in the context of teachers that believed in practicing SSIs teaching. Teachers were assuming various roles, developing their own teaching approaches to ensure that students would benefit the most of their SSIs teaching. A noticeable finding from my study, specifically concerning the teachers categorised under profile-A and profile-E, is that the teachers were flexible in assuming various roles for teaching SSIs depending upon what they thought was important for students. Teachers belonging to other profiles portrayed inflexibility in changing their perspectives. The change in identities of teachers, as appropriate for the teaching context is similar to some teachers that exhibited similar behaviour in studies of Ryder and Banner (2013), Ryder et al. (2014).

7.4.2.6. Teachers' dilemmas

This finding is related to the dilemma, discussed in chapter 3, that the teachers in existing research works have reported about a need to maintain a

neutral perspective while teaching SSIs. Surprisingly, no teacher in this study explicitly mentioned that they want to maintain a neutral perspective in the classroom while teaching SSIs. In the study by Lee et al. (2006), some teachers refrained from teaching SSIs as they felt they might influence students with their own personal perceptions about SSIs. In my study, teachers' views contrasted to the views of teachers from Lee et al. (2006) study, as they felt that they need to talk about their own views about SSIs to students for them to gain from teachers' experiences, without imposing their views on students. Some other studies as well (Anagün and Özden, 2010, Cotton, 2006, Sadler et al., 2006, Topcu et al., 2010), presented similar dilemmas of teachers to remain neutral while teaching SSIs, whereas in my study teachers did not report on any need to remain value-neutral in the first place.

The need to remain neutral while teaching SSIs hints towards the teachers' beliefs about students. For example, Lee et al.'s (2006) study teachers wanted to remain value-neutral as they feared that students might grasp teachers' beliefs in the same way they would grasp a chemical equation or a mathematical formula. Teachers in the studies by Ekborg et al. (2010), Lee et al. (2006) discussed the immaturity of the students as a possible reason for a need to remain value-neutral, and at times the reason for not teaching SSIs. In my study, some teachers reported on their beliefs of students as immature to handle SSIs discussions. One teacher's actions were similar to those reported in previous studies, as he believed the students that do not even have basic values like respecting their teachers and elders are not capable enough to learn about ethics and values of SSIs. His expressed ideas seemed hard to be defended from pedagogical point of view; however, in context of his personal biography and his views about teaching of SSIs they seem defensible. Some other teachers contrasted with the findings of existing research as if they believed students were not mature enough they adapted the teaching method to a way to help the students build strong arguments.

One of the other interesting findings in this study was that at no point any of the teachers (interviewed) commented on their own lack of pedagogical skills or knowledge as a limiting factor for the teaching of SSIs, or showed any doubts towards their capacity to handle multiple-perspectives laden SSIs teaching. This contrasts

findings of many other researchers that researched teachers views on the teaching of SSIs, e.g., (Barrue and Albe, 2011, Forbes and Davis, 2008, Lee et al., 2006, Wallace and Kang, 2004), that highlighted the reservations of the teachers in their studies about their ability to handle multiple perspectives and to respond to students queries. The teachers in my study even reported being reasonably well prepared for the teaching of SSIs and would be teaching SSIs, if only for the constraining factors such as school leadership, parental pressure, time constraints. It well could be that these factors are the sole reasons for teachers not teaching SSIs, as reported by the teachers, or as pointed by (Oulton et al., 2004a, p.204) "*teachers reporting that they felt 'reasonably well prepared' may be at risk of deluding themselves*".

7.4.3. Other influencing factors

A range of other influencing factors was delineated in this study. These factors can be categorised in personal, internal and external contexts, as delineated by Goodson (2003). These factors include, among others, teachers' authority, students' response towards the teaching of SSIs, pressure for high attainment, availability of teaching resources, assessment system, departmental conflicts, time and curriculum pressures, and expectations of parents.

Teachers that were not conferred with the authority to make decisions regarding curriculum taught in their classrooms felt restricted to implement any new ideas or approaches in the classroom. The restrictiveness arose as teachers had to take permissions from their leaders before introducing a new teaching method or activity which they believed would be beneficial for students, and in some schools the teachers were assessed on their performance (primarily at the level of compliance to the curriculum path designated by department heads) by their department heads and feedback from students. The resulting pressure and interference from department heads led to a lack of motivation in teachers and impacted their teaching goals. This relates to the findings of Pearson and Moomaw (2005) that teachers' authority is connected to teachers' commitment, it is paramount for school leaders to confer teachers with authority to ensure the success of any policies or plans (Ingersoll et al., 1997).

In a similar vein to the conflicts related to teachers' authority, the conflicts within a department also significantly impacted the teaching of SSIs. The lack of collaboration and relation between the teachers within the same department resulted in conflicts that for a few teachers, e.g., Jane resulted in the alteration of teaching goals. In the context of this study, this shows the combinational impact from the conflicts due to teachers' goals, school leadership, and teachers' authority.

For science teachers, there is a need to reflect on their personal concerns and values to develop a larger vision for the new conditions of science and society (Anagün and Özden, 2010). This reflection could help students not to plunge into feelings of frustration or helplessness but to develop their own way to look at the societal changes on the basis of their values, beliefs, and scientific knowledge. Vice versa, the teachers are also influenced by the response of students. The enthusiasm of students towards a particular topic or a teaching method assures teachers of their efforts in a particular direction. Another set of factors that when considered together had a significant impact on the teaching of SSIs in this study. Parental pressure, pressure for high attainment, external examinations, time and curriculum pressures were interrelated to each other, and when present, the interplay of these factors created situations where it was difficult to teach SSIs from teachers' perspective. In the Indian context, there is a high pressure from parents and society from early stages of a student to perform well to be able to secure an economically-viable career. The situation is further exacerbated by the pressure to do well in external examinations for admission in professional universities after schools, which typically have low acceptance rates (partly due to the high population of India) and demand high grades. Teachers, in this study, felt that they were accountable for such expectations from parents and school leadership. These pressures were related to the pressure to cover the curriculum on-time before exams. When the curriculum that was deemed important for exams was lagging the SSIs teaching activities were reduced or stopped by almost all the teachers in this study. Time and curriculum pressures are more pervasive issues in SSIs teaching that have been mentioned in many previous studies, e.g., (Anagün and Özden, 2010, Barrett and Nieswandt, 2010, Gardner and Jones, 2011, Lee et al., 2006, Reynolds, 1996, Ryder and Banner, 2013).

7.5. Educational Significance, Implications and Recommendations

The interviews and observations data helped me build an understanding of the teachers' beliefs about the teaching of SSIs, and the factors that limit or facilitate the SSIs teaching for teachers. For the sample of teachers in my study, the main findings indicate that the school leadership and teachers beliefs' play the most significant role in shaping the discourse of SSIs teaching. Although more empirical evidence would be required to further strengthen the findings of this study, I present in this section the possible implications of the findings of my study.

7.5.1. Goals of science education in India and implications of my study

Before addressing the significance of this study in the Indian context, below I present the excerpts from a position paper drafted by the Indian national focus group on science teaching, which serves as a guideline for science curriculum designers. The following excerpt features in the position paper as an answer to the question – "How do we ensure that science plays an emancipative role in the world?"

> *"The key to this lies in a consensual approach to issues threatening human survival today. This is possible only through information, transparency and a tolerance for multiple viewpoints. In a progressive forward-looking society, science can play a truly liberating role, helping people out of the vicious circle of poverty, ignorance and superstition. In a democratic political framework, the people themselves can check the possible aberrations and misuse of science. Science, tempered with wisdom, is the surest and the only way to human welfare. This conviction provides the basic rationale for science education" (NCERT, 2014, p. 2).*

It is evident from the above statement that the "basic rationale" for science education in India is for the students to have the scientific knowledge and open-mindedness to tolerate multiple viewpoints related to the prevalence of science in society. It has been recognised that growing potential threats to human survival by the misuse of science, such as industrial pollution, can be addressed by awareness

and wisdom of citizens. Despite this focus on SSIs in the guidelines provided by the National focus group, the majority of the teachers in my study seemed to be unaware of any such goals of science education. The teachers (in my study) considered socio-scientific issues as an important tool and their profession as a pathway to addressing the changing demands of science and society, but they were primarily motivated by their personal beliefs. Even these teachers were not aware of the science education goals from National focus group and were primarily motivated to teach SSIs by their personal beliefs. This could be a consequence of the fact that the science teaching goals are not clearly communicated to the schools and teachers. Another possibility is that the teachers do not review systematically the curriculum goal documents and curriculum guidelines, except perhaps the science textbooks.

There have been recent reforms to the national level curriculum and assessment system in India that emphasise the environmental and ethical validities in the aims of science education. However, despite these reforms, the overall picture revealed by my study is different from what National Focus Group aimed for. For instance, the priority in science teaching is still ensuring the academic success of students in examinations rather than the goals specified by National Focus Group. My study provides an insight into the possible reasons for the disparity between the intended and the enacted science curriculums. The findings of my study could be instrumental for a reform targeted at the teaching of SSIs in Indian schools. Although my findings would require further substantiation with more empirical evidence, however, some of the results, in particular the importance of teachers' beliefs and the role of school leadership could be generalised to a broader context, especially in the developing countries that have an education system similar to that of India's.

The teaching methods employed with various strategies (in context of SSIs) have been discussed in my study. Further, the rationales given by teachers for selecting particular teaching methods have also been discussed in detail. These findings related to the teaching methods could be instrumental for the curriculum designers, school authorities that aim to develop or implement the teaching-learning methods that work for teaching SSIs. Although a direct adoption of the teaching methods / strategies (presented in my study) might not be feasible for the teachers as each teacher has his/her teaching competencies and method preferences, but the findings from my study could be personalised by the teachers for teaching SSIs.

Another interesting observation in my study was that although many teachers espoused the teaching of SSIs important for scientific literacy and preferred conducting discussions and debates for teaching SSIs, they ignored these issues and activities (discussions and debates) in favour of other examination-relevant topics before exams or when they had less time. The change in the teachers' focus could be traced to the seemingly conflicting goals of science education from the National focus group. In teachers' position paper by National focus group, the goal of science education is clearly aligned to SSIs teaching - *"The science curriculum up to Class X should be oriented more towards developing awareness among the learners about the interface of science, technology, and society, sensitizing them, especially to the issues of environment and health, and enabling them to acquire practical knowledge and skills to enter the world of work."* (NCERT, 2014, p. 11). The position paper and the science textbooks further have suggested discussions and debates for teaching SSIs. However, despite aiming at the teaching of SSIs as important and suggesting discussions and debates as teaching methods, the position paper at separate instances considers discussions and debates as extra-curricular methods and mentions that the discussions and debates "*should not be included for formal assessment*" (NCERT, 2014, p. 16). The focus of this position paper on teaching and assessing factual knowledge of students and considering discussions and debates as extra-curricular activities dilutes the SSIs-oriented aim of science education. In order to make any improvements in science education of India, the first and foremost task should be addressing such contradicting statements on SSIs teaching in the science curriculum and teachers' position paper.

Furthermore, to the best of my knowledge the NCERT science textbooks or the given position paper do not mention argumentation as a key component to achieving scientific literacy goal. Argumentation, as observed in teachers' interviews, is considered to be a negative element, which depicts two persons having animated exchange of ideas. Hence, there's a need to make teachers aware of the argumentation process and introduce argumentation as a teaching strategy for SSIs. I believe that teacher development programmes can be instrumental in this context, which focus on the creation and evaluation of arguments by a framework, such as TAP (Toulmin, 2003).

The further implications of my study concern the importance of teachers' beliefs. The most recent assessment system reform in India at the national level was introduced with a pilot in very specific settings. The reform was formed, without much feedback from the teachers who are the actual implementers of the reformed assessment system. Teachers' beliefs have been encountered as one of the most significant factors in the teaching of SSIs. Hence, as Lee and Witz (2009) correctly pointed out that any reform efforts without considering the beliefs of teachers would be ineffective. Although the teachers that strongly believe in the inclusion of SSIs in science curriculum would continue to teach SSIs, despite the impeding factors; the teachers that want to teach SSIs but do not have beliefs strong enough to overcome the impeding factors might be motivated to cover SSIs with right reforms that consider teachers' beliefs and their identities. A detailed set of recommendations (for school leadership), based on individual teacher profiles delineated in my study, has been discussed further in this section. In addition to not considering teachers' views, the assessment reform further lacks any assessment of discussions and debates. Including such teaching methods as a part of the formative assessment system would encourage the teachers to conduct more interactive activities with students.

In the current state, it was witnessed that teachers have certain misconceptions about the notion of SSIs themselves. Teachers' development programmes and the national education board in India shall address such misconceptions and as suggested by Lee et al. (2006), the developments programmes shall help teachers understand the ground characterisations of SSIs and the ways to implement them. The current science teacher education system in India does not focus on SSIs teaching at all; neither does it include any module to prepare teachers for teaching SSIs. As Anagün and Özden (2010) suggested it is difficult for teachers to adapt to SSIs teachings when pre-service teacher programs do not focus on SSIs teaching. For instance in my study, the teachers that dichotomised SSIs to a right-wrong problem have basic misconceptions concerning SSIs and changes in teacher education system can be effective in such cases. For the teachers to be proficient at handling controversial multiple-perspectives laden issues, the teachers should themselves be knowledgeable and sensitive to the implication of the controversial issues. This idea of the teachers' ability to handle multiple perspectives has also been discussed in an official vision document (Rajput, 2000),

prepared by NCERT on demands for the transformation of education system in India by the Indian Government. It states “Teacher education programmes will develop in teachers a new insight about plurality of perspectives." (Rajput, 2000, p. 36). When teachers are fully aware of the nature of SSIs, implications of SSIs on society and the aims of scientific literacy, then they would recognise such activities as a building block for informed citizens of the nation. In my opinion, much can be gained by integrating the sort of skills required for learning about SSIs into the teacher development programs, science curriculum, and the assessment system.

7.5.2. Implications at the level of individual schools

Both contextual and teachers’ personal factors showed an impact on the teaching of SSIs in my study. It is important to address both the sets of factors to ensure the effective teaching of SSIs. Addressing the personal factors for a teacher is more likely to yield expected results, but it is not as straightforward as addressing the contextual factors. Hence, the first step in this context would be to address the contextual factors for the schools. Below I present implications for the contextual factors, followed by the recommendations for addressing the personal factors.

School leadership is the most prevalent contextual influencing factor in my study. The leadership styles that are more inclusive of teachers’ ideas and provide deontic authority to teachers in the decision-making process seemed to be effective in the teaching of SSIs, whereas the lack of consideration in the decision-making process deters the motivation and morale of teachers. To overcome this major impeding factor related to the school leadership, it is recommended that leaders shall work towards creating and sustaining a school culture that is conducive to high morale, motivation and strong ownership towards SSIs teaching. Evans (2001) labels such a leadership as a ‘teacher-centred’ leadership, where the school leaders assume same responsibility towards endeavouring teachers’ needs as they expect the teachers to assume towards students’ needs, growth, and achievement. For instance, rather than impelling the teachers to implement curriculum related decisions, considering teachers’ opinions during curriculum / methods planning phase can mitigate the problems related to the conflicts in teachers’ identity. School leadership impacted teachers’ job satisfaction, commitment and ownership to the teaching of SSIs and to some extent their emotional state. A focus on leadership reform is important in the Indian context, with attempts to introduce characteristics similar to that of

democratic or distributive leadership style. This is necessary to improve the trust and communication between teachers and school leadership. An environment of trust is more likely to drive teachers towards pooling their knowledge and skills to achieve a shift towards the teaching of SSIs. The increasing involvement of teachers in the decision-making process is required, as teachers are responsible for dealing with students and implementing the curriculum related decisions. Hence, curriculum related decisions should not be solely taken by leaders and should involve teachers to improve the ownership of teachers towards the teaching of SSIs. There's a dire need for school leaders to work closely with schoolteachers. School leaders that have knowledge and expertise in science and are versed with the ideas of SSIs are important, as leaders without epistemological knowledge are less likely to infuse any inspiration in teachers. Hence, along with leadership reforms I would also recommend SSIs related development programmes targeted at leaders.

In addition to supporting teachers in the above-recommended manner, schools need to focus on the teachers' personal factors. One possibility thereof could be to introduce tailored workshops and development programmes for the teachers with different profiles, delineated in Chapter 6 based on the teacher profiles delineated by Sadler et al. (2006) (see Table 2.1) or the model citizen, model individual, model scientist, and model teacher profiles by Barrett and Nieswandt (2010). Table 7.2 shows the profile-wise suggestions for motivating the teachers to teach SSIs. As indicated in the table, each teacher profile has specific problems and it is difficult to provide a single solution that fits the needs of each profile. It must be noted that the table does provide recommendations aimed at a gradual change in teachers' beliefs and poses the change in beliefs as an important precursor to an actual change in the teaching practices, but it no way undermines the difficulty in doing so. The beliefs are formed over a significant amount of time, ranging years or even decades, and bringing a shift in one's beliefs can be an arduous task. Further the teachers could have legitimately diverse professional opinions about the curriculum, and the recommendations do not mean and should not be considered as any hint towards illegitimacy of any forms of beliefs held by the teachers.

Table 7.2.Profile-wise Suggestions for Motivating Teachers to Teach SSIs

Profiles	Suggestions
Profile-A	• Training should be provided to familiarise teachers with the intricacies of SSIs teaching. Teachers could be given training and prepared in way that they are able to more effectively teach SSIs, and focus on the regulations laid by the current assessment system.
Profile-B	• Training in teaching of SSIs and handling discussions with multiple viewpoints; • School leadership should play an active role in understanding the impeding factors for the SSIs teaching.
Profile-C	• Active cross-disciplinary collaboration between humanities and science teachers (as a learning process for science teachers). • Teacher education programmes should focus on helping Profile-C teachers think about their responsibility as a science teacher in discussing ethical aspects of science with their students. • Teacher learning programmes should be aimed at providing teachers with opportunities to understand the place of ethics and values in science educations, and the different ways in which they can discuss them.
Profile-D	• Long term teacher learning programmes should be organise that give teachers the opportunities to think about the relationship of science and ethics. • Reflective exercises with peers from Profile-A or the teachers with experiences of teaching SSIs to help the Profile-D teachers see the ethical aspects of science.
Profile-E	• Teacher Learning Programmes that encourage teachers to understand the place of ethics in science, i.e., outside the horizon of their own ethics.

Another possible alternative, considering the different profiles of teachers, could be to introduce a multi-level teacher-learning programme that covers the needs for all the teachers. Such a teacher learning-programme can be introduced both by the individual schools and by the educational boards. Most of the existing teacher-learning programmes focus on the teaching practices or the new teaching

methods, but a multi-level teacher-learning programme could be designed such that it is conducted in two stages. The first stage of the programme should focus on teachers' beliefs towards teaching of SSIs. Teachers that do not believe in teaching of SSIs do not teach it irrespective of the reforms or trainings (Barrett and Nieswandt, 2010). Even if the teachers follow the reforms or practice-oriented teacher-learning programmes, the results might be temporary or superficial. In order to have long lasting impacts, (although difficult to achieve) a shift in teachers' beliefs towards SSIs teaching is required. In the second stage of the multi-level teaching programme the development of actual SSIs teaching practices could be targeted.

In the first-stage of the programme, the initial focus could be to help teachers understand the importance of SSI teaching (inclusion of ethics in science) and an attempt could be made to nudge the teachers' beliefs in the direction of SSIs teaching, especially for the teachers that outright reject the idea of any correlation between science and ethics, i.e., Profile-D teachers. This needs including sessions to expose the teachers to the teaching methods, scenarios, personal experiences, where they can see that the correlation between science and ethics exists, and it does impact the lives of students. The Profile-A peers of such teachers can play an important role in such a training programme, as the reflection with peers might support the process of changing beliefs. Further on, the Profile-C and Profile-E teachers could be targeted in the first-stage, such that the focus of the training is on understanding the importance of ethics in science and making the teachers understand the basic responsibilities of a science teacher. In the second-stage of the programme, the actual teaching practices of SSIs teaching could be targeted once the teachers are convinced of the role of SSIs in science education. The stage-two trainings on teaching methods, helping understand the plurality of perspectives could not just help Profile-B to Profile –E teachers but also Profile-A teachers that do already teach SSIs.

7.6. Future Research Activity

The study reported in this thesis was an attempt at exploring the teachers' perspectives and practices towards the teaching of SSIs in Indian science classrooms. It is surprising to me that given the significance of SSIs in science education, and the relevance of SSIs to our society little research has been conducted

on SSIs teaching in Indian context. In fact, there are no empirical studies in SSIs education in Indian context to the best of my knowledge. My study does make a significant contribution to that end, but more studies are required in Indian schools in general. As previously discussed in Section 4.3, the study is of exploratory nature and was conducted in schools from only three cities from one state (out of a total of 29) and a union territory (out of a total of seven) in India. Further research is required in other states to ascertain the generalizability of the results.

A clear disparity between what was intended as the goal of science education in India by curriculum designers (NCERT, 2014) and the current practices of SSIs teaching in the classrooms was witnessed during this study. There is a need for in-depth research into the possible reasons leading to this disparity and the ways for reducing it. The most recent reform in science education in India was made in 2005 (NCERT, 2005). An open research area thereof is the level of synchronisation between the goals of science education in the reform or the position paper of the National Focus Group (NCERT, 2014), and the teacher education program curriculum. From the information available in the research documents and other official documents I could manage to get, I could not find any explicit reference of focus on SSIs teaching in teacher education programme. The lack of appropriate training to teachers is one of the reasons behind the above-mentioned disparities. The research is required to understand why no efforts have been made to include the recommendations of focus group or the science curriculum reforms into the teacher education programs. Obviously, it is difficult for researchers to dictate what exact changes should be made in the teacher education, but some valuable propositions can be made from the research results. School leadership and teachers' beliefs have been delineated as the most important components that impact the SSIs teaching. These are the topics of utmost importance, which have not received required attention in the context of SSIs, particularly the role of school leadership. For example, the role of science teachers has been considered previously towards the success of reform efforts (Ryder, 2015), but the role of school leadership also needs to be investigated in depth to understand how the various leadership styles and structures across different geographies impact the implementation and eventually the success of the curriculum reforms. As mentioned in my study, the recent assessment reform of India did not take teachers' beliefs or school leadership into consideration. A large amount of effort goes into designing such reforms, but considering these two important facets could significantly enhance the possibility of

successful implementation of such reforms, and could reduce the gap between the curriculum designers' intentions and actual outcomes. In order to ensure, the various development programs need to be developed specific to the various profiles of teachers. As mentioned previously, all science teachers belong to different profiles and have different requirements when it comes to SSIs pedagogies. The teachers that do not even believe in ethics of science need to be first supported in order to transform their perspective towards SSIs. Hence, there is a need for tailored teacher development programs and research into the various intricacies of such development programs. A further area of research is to consolidate the various leadership styles in the schools and the possible measures that can be taken to ensure the teaching of SSIs across schools with different leadership styles.

Lastly, my research did not consider the students' perspective and their needs. I personally believe that it is important to explore how students form their values and outlooks, and develop themselves as integrated individuals in science classrooms. Although, this value-building process spans over a number of years, nonetheless, such extensive longitudinal studies with students can provide important insights into the value-building process, impact of SSIs teaching and indications for SSIsreforms.

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Appendix-A

Interview Protocol I

Background and Biographical details

1. Gender
2. Service year
3. Qualification
4. Subject background
5. Any prior experience in teaching

Questions

1. People have different views about whether or how science and society are linked. What is your view?

   -If so, then how…?

   -Can you tell me about any contemporary issues that have arisen in society because of science?

   - Have you ever been confronted with such issues in your society?

2. What is your view on these issues?
   - Have you ever read about these before?
   - Can you think of any more issues like this that you might have ever come across?
3. Can you think of a reason why any other person would disagree with your perception?
4. What do you think about the inclusion of these sorts of issues in the curriculum?

   -Why do you think so?

   - Probes like- What role do you think global warming or pesticide usage (topic centred) should have in the curriculum?

   -How important do you think it is that these issues should be added to the curriculum?

- Anything that you like/ don`t like
- Any change you wish to see in the curriculum regarding these issues

Interview Protocol II

5. Can you tell me about how you go about preparing /planning your teaching of (name of the topic)?

1.-How do you go about planning these sorts of lessons generally?

2.-Do you plan all the science lessons like this or do you follow a different approach for planning these sort of lessons (name of the topic included)?

- Do you work alone or in collaboration with other teachers? How?

6. How do you teach these sorts of issues (name of the topic that has been observed) in the classroom?

(a) What different methods do you use to teach these issues?

3.Probes include:

- What activities do you follow?
- How often do you follow these activities?
- What do you mean by the terms like debates, discussions, practical etc.? If used by the teacher.
- Explain with example.
- How do you conduct these activities in the classroom?
- Do you use activities written in NCERT books?
  - Why / Why not are you using these activities?
  - How relevant do you think these activities are?
  - How often do you use these activities?
  - Is there any particular time of year when you use these activities more?

(b) What are your objectives behind using these methods for teaching SSIs?

- Do you use the same methods for other science topics?
- How is the use of these methods different for teaching SSIs?

4.

7. Do you think the way you teach these issues in the classroom is different from teaching other science topics?

- What might account for the difference?

8. How effective do you think these methods are?

9. Do you think that teachers may vary in the way they teach these issues in the classroom?
    - What might account for the difference?
10. How do you think that your personal experiences and/or beliefs impact your teaching of SSIs?
    - Do you think same is applied for other teachers? Why?
11. Do you think the importance that you attribute to these issues vary with how you feel/think about these issues?

Interview Protocol III

12. How do you find teaching of these issues?
    - Any positive/negative experience that you generally experience while teaching these lessons.
    - Probing more in the details of factor like how time constraints affect the teaching of SSIs? How assessment system affects the teaching of SSIs? Etc.
    - * (explained below)
13. How do students respond to teaching of these issues?
    - Is it the activities that interest them (if they show any kind of interest) or the content?
14. What do you think about the controversial aspect of these issues when you teach them in class?

5. Probes to be included (if only, they think that the issue is controversial to teach)

- Have you ever witnessed any situation?
- Why do you think these situations arise in the classroom?
- How did you handle it? Explain with an example.

6.

15. Do you think that there are any situations that arise while teaching these issues and not other science topics?

-Why do you think these situations arise?

-Do you think this influences the teaching of SSIs? If yes, then how?

-Can you think of some other factors that influence teaching of these issues?

Appendix-B

News headlines that were used to introduce SSIs (Not all of them, but a few of these):

I. Pollution control body for ban on diesel vehicles in Delhi

7.The Hindu, Dated December 17, 2012

The Government today informed the Lok Sabha that the Environment Pollution (Prevention and Control) Authority (EPCA) has recommended that there is need to ban diesel vehicles in Delhi to prevent the emission of high smoke particles.

II. **India opposes 2020 deadline for DDT ban**

8.**Down to Earth (Science and Environment online) Dated May 4, 2013**

The proposal to commit to a deadline on a worldwide ban on pesticide DDT by 2020 was rejected at the sixth Conference of the Parties (CoP). The proposal was strongly opposed by India, the largest producer of DDT. India is the only country still manufacturing the pesticide dichlorodiphenyltrichloroethane, better known at DDT.

III. **Pollution from car emissions killing millions in China and India**

9.**The Guardian, Dated 17 December 2012**

Study published by the Lancet says the surge in car use in south and East Asia killed 2.1m people prematurely in 2010

IV. India braced for fireworks over GM aubergine ban

10. The Guardian, Monday 31 January 2011

The country's trial of genetically modified aubergine offers insight into how a developing nation can democratically tackle emerging technologies

V. Global carbon dioxide in atmosphere passes milestone level

11. The Guardian, Friday 10 May 2013

Climate warming greenhouse gas reaches 400 parts per million for the first time in human history.

VI. Siberia's pesticide dumps may prove a bigger hazard than nuclear waste

12. Guardian Weekly, Tuesday 27 November 2012

Across the former Soviet Union harmful agricultural chemicals were either buried or improperly stored. Now the process of clean-up has begun

VII. Indian coal power plants kill 120,000 people a year, says Greenpeace

13. The Guardian, Sunday 10 March 2013

The environmental group's report on pollution in the country warns emissions may cause 20m new asthma cases a year

Appendix-C

Observations Information Form

Date: _____ Teacher: _____

Standard: _____ Duration: _____

Subject: _____

Topic of discussion: _____

What are the main objectives behind teaching this topic?

What are the resources used for teaching this topic in classroom?

What are the activities conducted in the classroom for teaching this topic?

Observations and Notes significant to Research Questions

Notes:

Detailed classification of observation material:

- Introduction of chapter
- 1-way or 2-way communication
- Confidence level
- How were the activities / strategies executed?
- Strategies rating.
- Teacher response to students queries
- If no response from students, teachers' reaction to that.
- How much initiative did teachers take to discuss societal aspects?
- Management skills: handling classes, diversions etc.
- Students' Reaction to the strategies (Observations)
    - Did they ask questions if they had queries?
    - Did they participate in discussions?
- Was there any relevant discussion beyond the textbook boundaries?
    - Teachers handling these situations
- How was TLP process going on in the classroom?
- Pedagogical skills reflected in the classroom

Appendix-D

Consent and Information Forms

Information sheet for schools

Research Title: ''Teachers' perspective on teaching of socio-scientific issues (SSIs) in Indian science classrooms.''

- I invite the teachers in your school to participate in this research (as explained below). Please spend a few minutes reading this explanation in order to understand the reason for conducting this research. If you need any further explanation, please do not hesitate to ask at any point.
- This research is focused on the teaching of socio-scientific issues in Indian science classrooms. I plan to investigate: teachers` perspectives on the teaching of SSIs, different strategies and methods that they employ for teaching these issues and why, and the factors that influence the teaching of SSIs. I am not trying to judge their teaching, but I am interested in knowing their understanding, the approach that they follow and the ideas they hold for these issues.
- This research will be conducted in two phases. The participants will be asked to read an information sheet circulated to them and sign the consent form. The teachers who are willing to participate further in the research will be expected to allow me to observe their classes (2-3). Three interviews will be carried out with those teachers whose lessons have been observed. Each interview is likely to take 30-40 minutes and all the interview responses will be audio recorded.
- I need your help as well as approval to distribute the information sheets along with the consent forms among the science teachers teaching 7^{th}-10^{th} standard of your school.
- The participants have the right to decline to participate in this research. You can also withdraw from this research at any point without giving a prior reason.
- This research will protect teachers' identities and retain their anonymity.
- It is hoped that this work will contribute positively to research in science education in India as well as in the world. Apart from this, participating in this research will give teachers a reason to reflect on their teaching practice. Teachers might also think more about the factors that influence their teaching which will provide them with an opportunity to retrospect their teaching.
- If you require any further information or explanation, please email me on the following address: ed11vm@leeds.ac.uk .

Vasudha Malhotra

Information sheet for teachers for observation

Research Title: ''Teachers' perspective on teaching of socio-scientific issues (SSIs) in Indian science classrooms.''

- You are invited to participate in this research as explained below. Please spend a few minutes reading this explanation in order to understand the reason for conducting this research. If you need any further explanation, please do not hesitate to ask at any point.
- This research is focused on the teaching of Socio-scientific issues (SSIs) in Indian science classrooms. I plan to investigate: teachers` perspectives on the teaching of SSIs, different strategies and methods that they employ for teaching these issues and why, and the factors that influence the teaching of SSIs.
- If you have volunteered to participate in this stage of the study you have the right to withdraw from this research at any stage. You do not have to give a reason for your withdrawal.
- As per the requirement of this research at least two SSIs lessons will be observed. In total not more than 3-4 classes per teacher will be observed. The researcher will be a non-participant observer and his/her role is quite passive. The researcher will not take part in any of the activities or teaching process taking in the class.
- All the observations will be audio-recorded.
- Despite the fact that you will not be personally rewarded for participating in the project, it is hoped that this work will contribute positively to the research in science education taking in India as well as in the world.
- It is to be noted that this research is not conducted to judge your teaching but the researcher is interested in knowing the understanding teachers have about Socio-scientific issues, the approach they follow and the idea they hold for these issues.
- This research will maintain your anonymity by giving fictitious name to all of the interview participants. All of the information gathered will be utilized only for the benefit of this research.
- Any audio recordings of observation made during this research will be used only for data analysis. No other use will be made of them without your written permission, and no one, apart from the researcher and supervisors will be allowed access to the original recordings.
- If you require any further information or explanation, please email me on the following address: ed11vm@leeds.ac.uk .

Vasudha Malhotra

PhD Student

School of Education, University of Leeds

Leeds, LS2 9JT

Information sheet for teachers for interviews

- You are invited to participate in this research as explained below. Please spend a few minutes reading this explanation in order to understand the reason for conducting this research. If you need any further explanation, please do not hesitate to ask at any point.
- This research is focused on the teaching of scientific issues that are related to society in Indian science classrooms. I am not trying to judge teachers' method of teaching, but I am interested in knowing their understanding, the approach that they follow and the ideas they hold for these issues.
- If you have volunteered to participate in this stage of the study you have the right to withdraw from this research at any stage. You do not have to give a reason for your withdrawal.
- You will be interviewed three times. Each session of interview is likely to take 40-60 minutes and all the interview responses will be audio recorded.
- This research will maintain your anonymity by giving fictitious name to all of the interview participants.
- Any audio recordings of interviews made during this research will be used only for data analysis. All of the information gathered will be utilized only for the benefit of this research and no other use will be made of them without your written permission. Apart from the researcher and the supervisors no one will be allowed access to the original recordings.
- Despite the fact that you will not be personally rewarded for participating in the project, it is hoped that this work will contribute positively to the research in science education taking in India as well as in the world.
- If you require any further information or explanation, please email me on the following address: ed11vm@leeds.ac.uk .

Vasudha Malhotra

PhD Student

School of Education, University of Leeds

Leeds, LS2 9JT

Interview Consent Form

Researcher Name: Vasudha Malhotra

Official ID: ed11vm@leeds.ac.uk

1. I have read the Information Sheet for this study and have had details of the study explained to me.
2. My questions about the study have been answered to my satisfaction, and I understand that I may ask further questions at any time.
3. I also understand that I am free to withdraw from the study at any time, or to decline to answer any particular questions in the study.
4. I agree to provide information to the researcher under the conditions of confidentiality set out on the information sheet.
5. I wish to participate in this study under the conditions set out in the Information Sheet.
6. I consent to the information collected for the purposes of this research study and not to be used for any other research purposes.

Participant's Name: _____

Participant's Signature: _____

Date: / /

Contact details: _____

_____

Researcher's Name: _____

Researcher's Signature: _____

Observation Consent Form

Research Title: ''Teachers' perspective on teaching of socio-scientific issues (SSIs) in Indian science classrooms.''

Researcher Name: Vasudha Malhotra

Official ID: ed11vm@leeds.ac.uk

1. I have read the Information Sheet for this study and have had details of the study explained to me.
2. My questions about the study have been answered to my satisfaction, and I understand that I may ask further questions at any time.
3. I also understand that I am free to withdraw from the study at any time, or to decline to answer any particular questions in the study.
4. I agree to provide the permission to the researcher to observe the classes under the conditions of confidentiality set out on the information sheet.
5. I wish to participate in this study under the conditions set out in the Information Sheet.
6. I consent to the information collected for the purposes of this research study to be used for any other research purposes.

Participant's Name: _____

Participant's Signature: _____

Date: / /

Contact details: _____

_____

Researcher's Name: _____

Researcher's Signature: _____

Appendix–E

Sample Interview - Teacher Katie (School I)

I1: Do you think science and society are linked with each other?

R1: Yes, obviously science and society are linked with each other.

I2: Can you please explain this?

R2: Science has made society dependent on it. We are dependent on science more than our own selves. We are unable to do day to day activities without science as in like general use. I personally feel helpless when there is no electricity or any appliance is not working, when my mobile phone is not with me. Now we are addicted to the new inventions, if you have no access to the internet than you feel you are in a different world. If I will show you my phone there are so many apps in it, like wats app, we chat, skype, Facebook and so many other features. Now everyone has a camera in their pockets in form of mobiles. You know from past 10-15 years, science is now ruling us. It has obviously made our lives easier. I use to pile up a lot of books initially, but now everything is available on computers, laptop, e-library, so we don't have big volume of books now. See, being a female I say that my life is much easier than my mother-in-law or mother's life 20 years before. Now my life depends on automatic washing machines, microwave, and dish-washer. If I am today out of my home and teaching in a school along with handling my family than it is because now I have all these facilities. I can't imagine coming and teaching if I don't have all this in my home. It's convenient, time-saving and now I can concentrate on other things also.

I3: I completely agree with you and even I feel the same. Now, this is something that is related to your personal experiences and life-style. Will you like to add something at a larger societal level? Or I can say things that you think may link science and society at a broader horizon?

R3: Well, there are several scientific phenomena's and things like new inventions operating around us though we don't have much control over many phenomena's but still they are occurring. Because of science, we have the knowledge that how the phenomena occur, the phenomena that are

happening whether we realise it or not, how do they affect us and vice-versa. We can take preventive measure like the latest was detection of cyclone Phailin in Andhra Pradesh. The scientists or you say the weather people found it and evacuated thousands of people and this saved life of many people.

I4: So you mean the natural calamities like cyclones or typhoons can be predicted beforehand with the help of science?

R4: I will say yes, they are natural calamities, but science in the end helped us out. Like the equipment or the satellite things, they are an invention of science only. See the study may be related to geography but the things that they use to predict or detect are invention of science. Other things also, we can know the anthropogenic influence on environment and at least we can take steps to check that. It's like a give and take relation between science and society.

I5: So, this is all about the good things that you think science has given to the society. Can you think upon any negative thing that science has given to the society or may be any situations that are now present in society because of science?

R5: Obviously, we are not much aware of this. But we kept on hearing from different sources like newspapers and science magazines that electronic waste is increasing, radiations coming from these mobiles are hazardous, we even know that we should not keep the cell phones beneath our pillows but we still do it. I think it doesn't bother us as in really bother us. We have developed an attitude like let's see what happens… everyone is doing it, what difference does it make if I don't do... so we are having this kind of attitude in our minds. We cannot do without them, these things have become a necessity nowadays, they may influence us later on after some decades or next generation but who is bothered. I will tell you something more, we hear this so much that harmful pesticides are being used and it is having adverse effects on our health. In fact Bathinda (name of a place) has been declared as a cancer zone, but still after so many hue and cries, after taking so many actions, after creating awareness still farmers are using it. They say it's their livelihood, how will they serve their families if they don't use pesticides and the crops get damaged. But now the mind-set has become like that, now we are not bothered to give a thought about what is harmful for us. Farmers don't realise that the pesticides or insecticides get into the soil, seep in and mixes in

the ground water which in the end they drink. But still, no botheration. And they are the farmers, may be they are not so well educated but the educated people are also the same, they read in the books, in the school this thing is harmful don't do this, this may affect the environment don't do that. But the conclusion is they are not bothered.

I6: You just said that Bathinda has been declared a cancer zone and they are aware of it, but they are not bothered. What do you think might be the reason behind there carefree or I am not bothered attitude?

R6: There have been many awareness campaigns organised by government and NGOs to create awareness. Like I myself co-ordinated and supervised a project that was meant for class X regarding the cadmium toxicity in the soil and water near the Budha Nallah (a small lake, passing through the middle of the city, the area around this lake is highly populated). Our students found that the cadmium is a heavy metal and it traps in the plant and in particular near the Budha Nallah there is a lot of crop production and fisheries production. That is coming to the market, people are consuming it almost daily and our students scientifically proved it with the help of PAU (Punjab Agricultural University) authorities. It has been clearly stated that this is really harmful and toxic and is having drastic effect on our health. So I will say that people are aware and people are raising their voice against this but layman does not know how to curb that. They understand this, but no one bothers to give them a feasible suggestion or a solution. Now cadmium is coming from the industries especially the electroplating industries. We as teachers and the students also, can take initiative and can just raise the voice. My students were so involved in this project that they "actually" wanted to do something. But see the power lies in the hand of government; they are the people who have to do something. I personally feel that our job is done; we had a project, found the problem, proved it with facts and figures and raised our voice. Some of my students wanted something more they wanted to name some factories and ask the government to give them warnings or ban it if they don't stop all this. But after a point I feel that I don't want my students to be a part of a social controversy and that too like messing around big people. So I just told them that this is not we are meant to do. According to the education perspective our boundary line is this, and we can't cross it.

I7: Why do you feel so? I mean what makes you think that your job is done?

R7: Because nothing actually happens, we came to know that our report was taken seriously by the municipal corporation and even the funds were passed to clean the Budha Nallah, but you know the 'real' money doesn't go to 'real' people. So there is no point stepping outside your shoes and trying to do something for the people who are not even bothered. We kept on hearing things like billions of rupees were passed for the project and then we came to hear that nothing was done. Firstly the project stopped because of some political reasons and then they declared that this project failed. At our own individual level and at a student's individual level I suppose our job is done.

(Teacher took a pause here and then continued)

See people do listen to you, but government is having deaf ears. Our students even went to the villages to talk to the villagers and show them the consequences. Even the villagers were also quite perceptive, they do listen to you and I have seen this because I was also involved in the project. I did a project on "Influence of washrooms near the water bodies" and that is a very common feature these days in villages. Students went there and spread the awareness and after that there were changes. See you need to understand that India is quite big and the way people live and understand the issues is varying. See that particular village had a very bad drainage system, normally villagers use hand pump in their houses and they don't have proper washrooms. Because of that they go near the rivers and there is a lot of faecal contamination of the water bodies which further results in various diseases. We again involved ___ University in our project; we took their assistance and our follow up showed that the changes were there. Initially, we faced some kind of awkwardness on their part. May be because they don't understand the depth of the problem or maybe they are not at all interested but we did get positive results which boost our morale. So see, we are doing our bit, people are perceptive, but at a larger scale the government only can do something.

I8: So, the project, which you just described, was initiated by whom? As in you, school authorities, students or any external committee?

R8: There are certain projects initiated by the government. This particular was under Science Congress Project. Under these kinds of projects, the students

have to work in a group of five. Even the themes are given…; sometimes the theme is environment, water, use of pesticides and other societal scientific issues.

(There was disruption in the interview as she was called urgently by the principal of the school for few minutes)

I9: Can you please have a quick read of these news headlines and then we will proceed with the interview?

R9: <Katie reads the headlines>

I10: So have you read about these issues before?

R10: Yes, some of them. Like I know about the DDT ban and they are not banning it because some people are having their big businesses which they don't want to stop. I think in India production of DDT is quite huge. *(Looking at the headlines again)* I mean this show that people are creating awareness; I do have a bit of an idea about these things but not like sooo… much.

I11: What is your view about these issues? What do you feel about this?

R11: See, there are some people who are really concerned about this. It is not that no step has been taken, but the fraction of the people or say the percentage of the people who are concerned is really low. It is not like people are not concerned, they are concerned and there are many issues that are raised by people in general also. When I go into the park in evening to take a walk there are some groups of people who talk about these things. In past few years, we have seen many associations that have been formed and which are working at a small as well as large scale. See local bodies are doing whatever they can, but it is not consistent, government does take steps for the same but then it goes off soon.

I12: Can you please explain it with any example?

R12: For example introducing CNG autos (a three wheeler vehicle quite common in India and used as a public transport), was a step to curb the increasing emission of harmful and infact toxic gases and others like greenhouse gases like Carbon dioxide. Some more like sulphur oxide, nitrogen dioxide, carbon monoxide. But I tell you this is what government thinks, they banned the normal autos but still some use especially in outskirts of the cities and even in

villages. See the problem is we have a huge population, they make rules and they think the rules will be implied but this is not happening. They don't do the required follow up. The people do become enthusiastic to work for such cause but when they do not get support, then that zeal…. It just goes off. Like in our school when we initiated the project then we have to keep on giving a reminder, a follow up and it makes a difference. When our students went to the villages for the first time, then there was not much difference, then they went again and reminded them all of the stuff again… the next time they went, we could see the impact and the students were also so happy, they felt like 'yes' we have made a difference. This acted like a booster for them and they were like when we will start our next project. I tell you one thing, when we teach these things in the class then they learn it and may be understand it but just on the superficial level. So you know follow up should be done.

I13: What do you mean when you say that they learn it or understand it on 'superficial level'?

R13: I mean like… they don't take it back home in their heart. They learn it, understand the logic, sometimes discuss it, write it and forget it. This kind of teaching doesn't give them a sense of responsibility or say ,like the feeling that 'yes' this is our world, we have to do something. I have myself seen that if we teach them this in class they don't give an extra effort. They have so many other subjects to do, curricular and co-curricular activities, why would they be bothered. Here it is the teacher's moral duty to make them realise that this is something crucial and I tell you student's at this age are full with energy, if you show them the direction, they are like so passionate that they will find the way themselves. You just need to be there and make them realise what is their role. I have seen so many students especially boys who went to the village in their summer holidays like to do camping. They went there and saw how people burn the cowdung cakes and wood to make food, how they were burning the rubbish and the agricultural waste in huge mass. They were initially shocked because these activities contribute a lot in the greenhouse gases. But obviously these people don't understand all this scientific stuff. Our students help them understand the causes and the consequences. We were not aware of this, but when we went back to the village again and saw the bond that those students were sharing with the villagers, I personally felt that

we are going to make a better India. I feel this is my little contribution to my country.

I14: Can you think of a reason why any other person would disagree with your perception?

R14: I think it varies from person to person. I feel they are not aware that things have gone so much worse. And secondly, its their priorities, I am a science teacher I feel so may be others don't think like that. But if you keep a check then it is always good.

I15: Keep a check…??? Can you explain it with an example.

R15: For example, polythene bags were banned; they are banned in our schools also. But after 2 or 3 months reminder has to be made by the principal otherwise this just goes off. A follow up is must, a check has to be maintained. It's a human nature to go back into your comfort zone. So when the strictness is not there, then the students also get back to use polythene bags and same is with the society, initially they do then they forget and get back into their comfort zone. I feel if something is banned, then it is banned whether you like it or not you have to follow it. May be it seems so small, to ban poly bags but we have to face many things, many parents said they don't want this. They said school is getting footage like for media things. They were totally against it. You have to understand that there are some people who are thinking about these issues at much deeper level and they are doing it for your future betterment. Its always easier to go for your daily life events, be it be using poly bags by students, pesticides or insecticides by farmers, throwing toxic sewage by factories. But once the government has banned then it should be banned. You know people have a mentality that what difference does it make if I am using it or doing it. How does it matter if I am just doing it? They don't understand that it is every drop that counts to make an ocean. This attitude is the main problem. You must have seen that things have changed so much near Chandigarh, Punch Kula and in Himachal area. But over here its still the same, same industry people influencing the people in power and manipulating the rules.

We can keep on teaching and telling this thing to our students that individual effort makes a lot of difference. I have a habit at my home also that

I keep on switching off the lights when they are not in use. Initially my father-in-law, mother-in-law sometimes use to say that how does it matter? But slowly and gradually they also got the same habit, so you know things like this take time but can be done. Same in school also, if I am going in the corridor and I see the lights or fans are on when no one is in the classroom then I switch it off. Now students of my class also do the same, so these things can be incorporated if encouraged and supported. But once our school trip was there to America, the students came back with a completely different attitude. They said that mam you keep on telling us that don't waste water, switch off the lights etc etc. but over there no one saves light or water, everyone takes bath under shower rather than using bucket and same for the use of electricity. So you know those students attitude was completely changed

I16: That is a nice effort on your part. Now coming back to the issues that you have read in the headlines. You hold a perception about these issues and then you have just said that some people agree and some don't. So what do you think is the reason behind this different perception?

R16: I think it depends on individuals. Every individual is different. I think whenever you initiate something that may affect some people than there is a sort of rebel or you say difference in opinion. Those who agree they take part or you say support the cause and those who don't, they don't. See I believe that there is a difference in the sensitiveness of the people, some are more sensitive so they agree and others who don't are I suppose less sensitive if not insensitive.

I17: What do you exactly mean when you say that there is a difference in their sensitiveness?

R17: I feel that if you can think or say feel at a broader horizon then you are sensitive.

I18: Can you please explain it with an example?

R18: My grandmother use to say a saying that "Even an animal can also feel its own pain, you are human only when you can feel others pain too". This is my meaning of sensitivity, if you can consider others well being and overlook your meagre personal benefit than only you are a true human being.

(Thinks for a while and then picks up the paper with the headlines).

This would not have been happening if people had the conscious to understand that your factory is not producing just DDT but it is risking lives of millions of other people too. If government is giving benefits to the farmer like making them everything available on subsidise rates and sometimes negligible rates, then they also realise that it is their moral responsibility to provide us with a healthy crop not a crop that is doing much more harm than the nutrition it is providing. But they don't bother. May be because they are uneducated but the awareness is there, now there are people who make them aware of all the hazardous consequences on environment and people. But still they don't.

I19: Okay. So what do you think about the inclusion of these sort of issues in the curriculum?

R19: Of course, they should be included. They are very much there in the curriculum and CBSE has initiated environmental study also side by side for the primary wing.

I20: *(I pointed towards the news headlines and asked)* Do you think all of these are environmental issues?

R20: No, they are not. But what I see is that these issues have something to do with the student's conscience. You know like….. *(Thinks for a while)* Like they give you a point where you think that am I doing right, why I am doing so, why they are not doing that. Do you understand…, things like morally shake you for a while and shows you the two sides of the coin or may be more (*took a pause)*. See in NCERT books especially till 10th standard you can find more about environmental. Other things are there but in higher classes. See whenever there is an issue like this especially environmental issues, CBSE sends us a circular to conduct some activities with the students so that it develops their mindset or say gives them that zone to think about these issues and may be take a message or mindset with them to their homes. And apart from this, these things are made a part of the curriculum like the assessment system. We have FA's (Formative Assessment) where we include that topic as a part of one of the assessment. See its both ways, sometimes students are quite interested in such kind of topics as they feel it is their time, sometimes it is like they are not bothered, so when it is a part of the assessment then they listen to you also and take part in the activity also.

I21: Why do you feel that sometimes students are not interested and sometimes they are?

R21: I think its not much about the student, its more about the teacher. If the teacher is not so good in handling or I should say she is not making the topic interesting enough for the students then the students feel detached with the topic. So they do it, but that sort of passion… passion is not the correct word, but you can see that they are 'in' the topic and they are not distracted. It doesn't use to happen before now we are having themes that are declared in the beginning of the session like International year of Biodiversity and we usually have a week long workshop happening around different age groups and activities are decide according to their age group only.

I22: What exactly do you do in these workshops?

R22: See, it depends on class to class. Like for the junior students, let's say till 8th class. The main motive is to make them aware and conscious about the topics. So we do the activities that they find interesting as well as easy to do like for 6th standard we have group activities, they are asked to bring pictures and find information on the topics.

I23: Can you name some few topics?

R23: That also varies, there is a list of issues that includes issues like deforestation, pollution, global warming, ecological changes happening in environment, how it is affecting the biodiversity. The choice of topic primarily depends on the age range and the activities also, its more of learning by doing for junior classes and vary from scrap book making by collecting the news headlines or articles from science magazines, poster making, collage making, quiz contests on the topics and many things like this.

I24: Are these activities effective?

R24: Yes, of course they are. These things do help. See we do it with a perception that if we are able to change even 1% and not exactly even change like aware them, making them explore their mind and get that thought process into action. For example in our school, campaigns go around and student from all the classes are encouraged to take part. Like Diwali is coming, so we have students of 6th to 8th standard who are campaigning around the schools to create awareness about how and why we should avoid burning crackers, how

it affects the environment; so they want to make difference. And some parents understand and encourage it but some families don't and they go the same way. So again it is what you feel like doing. Students do play their part but again it depends are they supported or not.

I25: So how important do you think it is that these issues should be added in the curriculum?

R25: It has now become quite important. I think the situation has become alarming and the only way government can change the things, which have been going on from past few years or say decades, is to infuse these things in the mind of the youngsters. If they develop that sort of mind-set or say they get that logic clear in their mind through the science then only they can make the change that is required. Moreover, when they learn these things, understand the logic behind the different aspects and use their own mind to analyse the situation, then the go one step ahead and can relate or understand other's point of view and may be they can defend their point logically.

I26: Can you please elaborate, how can the students defend their point of logically?

R26: Like, my daughter who is in 7th standard was taught about air and water pollution in her class. She came back home and narrates it to her grandfather and grandmother. So once they went to a river and 'pravah' (a hindu ritual in which few things are flowed into the river which results in pollution and is controversial in the sense that it cannot be banned as it is directly related to religious beliefs but scientists are opposed to the same) few things in the river, she opposed them. But they just told her that you are too small to comment on this and brought her back home. So you know it does makes a difference.

I27: Then what role do you think issues like pollution or global warming or pesticide usage have in the curriculum?

R27: I think the basic idea is to teach these things and make the youngsters aware of the current situations. And the students these days are active, if they like something then they do go ahead and tell others about the same. I think coming generation will be much aware. If we don't teach these things then the little awareness or say the little difference that we are making today we wont be able to do this much also. So the effort should keep on going. Difference

may be minor but efforts should keep on going. Nowdays, there are many societies and associations who involve young students and they are doing a lot of team work beyond the school boundaries to create awareness about the same. We also see that there are many channels on the television which make such kind of programmes. We asked some of our students of 10th and 11th class to see a video, it was a Discovery Channel video 'Global Warming-What you need to know'. After students watched it, they had so many strong opinions. They actually said but mam may be its good, because than there will be more carbon dioxide and then there will be more chances of survival of plants. So you know, you don't know what is cropping in their minds, but our efforts continue.

I28: So the video that you are talking about, this was shown in the classroom as apart of teaching or the students saw it themselves?

R28: To be very true, I had no idea about this video, but our environmental manager (the person who teaches environmental topics present in science textbooks like global warming, green house effects, ozone layer depletion etc.) asked them to see it. She usually teaches for just one day; one or two lectures per week and that too on Friday and Saturday. So the next Monday when the students came to school, they were ready with so many questions and they were discussing and arguing with each other. I had no idea with what they have seen, so I just told them to discuss this with their environmental manager and concentrate on the topic that I was teaching them. They were initially not happy, but if you look at my position I can't comment unless I have not seen that video. You should talk to our environmental manager; she will have so much to say about all this.

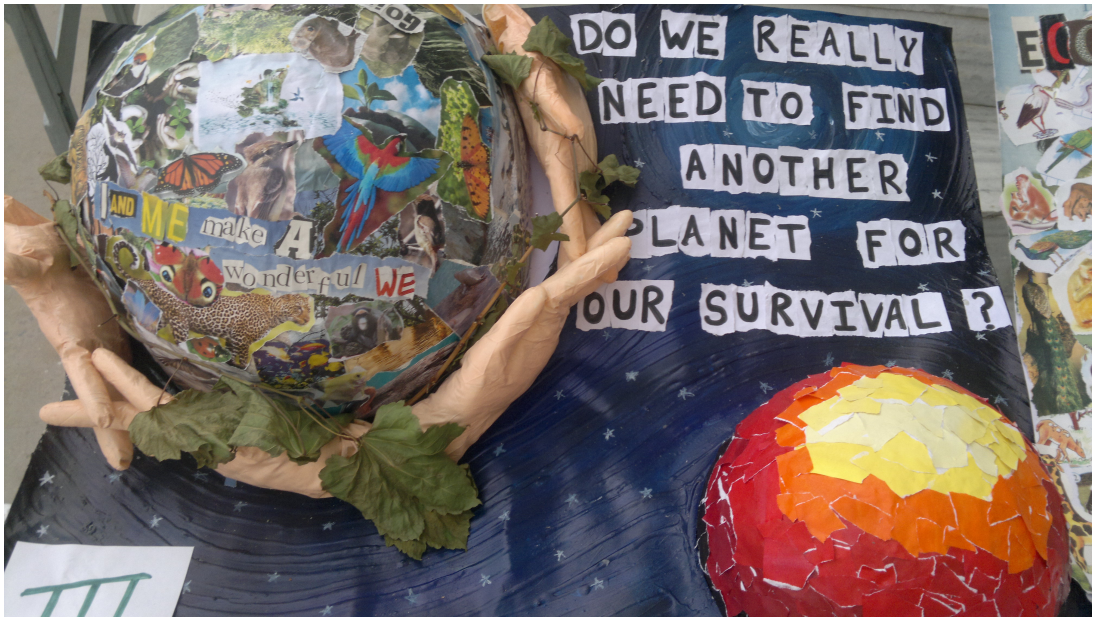
I29: Thanks for telling me this. I will surely talk to her. So do you want to add something more to this?

R29: No, I think you should talk to Mrs. _____ she is so into this that you will come to know so many more things from her. Her efforts inspire us also.

I30: Thanks a lot for your time. I will get back to you soon.

Appendix-F

Artefacts from Observations – The posters prepared by the students as a part of their environmental SSIs learning in the three Green Schools, such as MPE, Earth Day, Green Walk. Some of the pictures had faces of the students or teachers and have not been added for confidentiality purposes.




EARTH DAY...
FREE AT LAST!
ELEMENTS OF NATURE
EMBRACE MOTHER EARTH


I Am Not An
Environmentalist,
I Am An
Earth Warrior.


STOP GLOBAL WARMING
CHANGE
CLIMATE
SAVE
HUMANS
HAVE A BIG
CLIMATE CHANGE
HAND IN
I gave you
life, now
your time
reciprocate
One world
one chance!
CO2
FLOOD