Conceptualizing Critical Science Education through Socioscientific Issues

A thesis

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by

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DECLARATION

This thesis is a presentation of my original research work. Wherever contributions of others are involved, every effort is made to indicate this clearly, with due reference to the literature, or acknowledgement of collaborative research and discussions.

The work was done under the guidance of Professor Sugra Chunawala, at the Tata Institute of Fundamental Research, Mumbai.

Aswathy Raveendran

In my capacity as supervisor of the candidate's thesis, I certify that above statements are true to the best of my knowledge.

Date:
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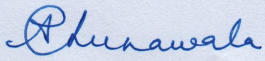

Sugra Chunawala

Thesis Supervisor

To

My mother,

Latha Karuthedath

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TABLE OF CONTENTS

LIST OF PUBLICATIONS

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LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ART	Assisted Reproductive Technology
CSE	Critical Science Education
CSL	Critical Scientific literacy
FSS	Feminist Science Studies
G-P	Genotype-Phenotype
IVF	In Vitro Fertilization
LOD	Levels of Disagreement
NCERT	National Council for Educational Research and Training
NCF	National Curriculum Framework
NOS	Nature of Science
POS	Philosophy of Science
RCH	Reproductive and Health Care
SL	Scientific literacy
SSI	Socioscientific Issue
STS	Science, Technology and Society
STSE	Science, Technology, Society & Environment
S & T	Science and Technology
TAP	Toulmin's Argument Pattern

ABSTRACT

This thesis seeks to emphasize a vision of science education that draws on critical perspectives that place science within the social, political and ethical context. Broadly, it synthesizes theoretical perspectives that support this position, employing these to critically examine the national science curriculum documents pertaining to science education and the higher secondary biology textbook (chapters 2 and 3). Further, it reports exploratory empirical work done with higher secondary[1] biology students where they negotiate a controversial socioscientific issue (chapters 4 and 5). In chapter 6, I argue that critical science education should persist in higher education, reviewing initiatives in higher education that articulate this need. Here, I employ the example of genetic determinism and the potential it affords to helping students understand science as situated in a sociopolitical context to further develop my ideas on critical, contextualized science education.

1 Secondary education in India caters to students between the 12-18 age group, the final two years of which constitute higher secondary education. At the higher secondary level, students choose between the humanities, commerce or sciences, undertaking specialized education in these streams.

CHAPTER 1

DEVELOPING A THEORETICAL BASIS FOR CRITICAL SCIENCE EDUCATION IN INDIA

1.1 Critical studies in science education

This thesis can broadly be placed within the area of critical studies in science education. As Bazzul (2016) writes, “The goal of a critical scholar (of science education) is to render what seems commonsensical, strange”, which I interpret as challenging mainstream science education, critically questioning the science curriculum, the ideological assumptions that underpin it, and positing alternatives (Bazzul, 2013; Bencze & Carter, 2011; Carter, 2005; Cross & Price, 2002; Hodson, 2003; Raveendran & Chunawala, 2013). Research in this area, in Levinson's (2013) words, “embrace feminist, post-colonial, critical pedagogy agendas and broadly aim to interrogate the representations of science education in a social world distorted by late capitalist and neo-liberal economics” (p.113). The theoretical perspectives that inform this area of research are derived from a range of areas that span philosophy of science, educational philosophy, sociology of science, science studies, sociology of education and Science–Technology–Society (STS) studies, to name a few. These perspectives have been operationalized in empirical investigations involving students and teachers (Bencze, Sperling & Carter, 2012; Levinson, 2007; Roth & Lee, 2004).

Many of these studies (both theoretical and empirical) also call for inculcating, in students of science and the lay public alike, *Critical Scientific Literacy* (CSL) and advocate politicization of the science curriculum (Dos Santos, 2009; Hodson, 2003, 2009; Mayberry, 1998; Roth & Désaultels, 2004; Weinstein, 2009). Before I proceed to a discussion of critical scientific literacy, I first discuss the concept of scientific literacy. The term Scientific Literacy (SL) is used to “express what should constitute science education for all students” (Roberts, 2007). The term is politically and intellectually contested and multiple meanings have been attributed

to it. Douglas Roberts (2007), in an extensive review devoted to laying out the meanings of SL identifies two positions that have “come to represent the extremes on a continuum”. He terms them Vision-I and Vision-II. While Vision-I represents a view of SL that emphasizes the “cannon of orthodox science” – “products and processes of science itself” in the curriculum, Vision-II advocates SL “through situations with a scientific component” – situations that students are likely to encounter as citizens (Roberts, 2007). Roberts points out that “considerations other than science”, such as ethics and values are also emphasized in this vision of scientific literacy.

In the Vision-I to II continuum, I position myself at the Vision-II end, and advocate critical scientific literacy, that questions the power relations that exist in society, the complicit role of science and technology in reinforcing the resultant inequities, and aims to foster social justice concerns in students. Hodson (2011) succinctly summarizes what constitutes the functions of critical SL :

> ... the most important function of (critical) scientific literacy is to confer a measure of intellectual independence and personal autonomy: first, an independence from authority; second, a disposition to test the plausibility and applicability of principles and ideas for oneself, whether by experience or by a critical evaluation of the testimony of others; third, an inclination to look beyond the superficial and to address the ideological underpinnings of science and technology, the economic and political structures that sustain them, and the norms and practices that accommodate some views and some participants but marginalize or exclude others; fourth, sensitivity to the complex interactions of class, race, gender, language, knowledge and power; fifth, an ability to form intentions and choose a course of action in accordance with a scale of values that is self- formulated; sixth, a commitment to criticism and constant re-evaluation of one’s own knowledge, beliefs, attitudes and values. (p.27)

What I argue in this thesis, however, moves beyond advocating critical scientific literacy at the school level for future citizens. A critical science education needs to persist through to higher education, even in the science curriculum that caters to specialists. Effort needs to be directed at both ends – through the school level to the doctoral level. This concern is also

echoed in Cross & Price (2002) :

> There is an urgent need for a new generation of scientists and technologists who have a better understanding of the nature of science, who can understand it in its social context. If they are not trained differently the much-needed reform of science may not occur. In addition to the concepts and skills of traditional science courses, the kind of teaching we are advocating will introduce that interest in, and concern for, relating science to the needs of the wider community which is so essential today for specialist and lay person alike. (p.99)

To some extent, the goals of critical science education have been realized in some of the Science-Technology-Society-Environment (STSE) initiatives in science education. In the next section, I provide a brief overview of the history and evolution of STSE initiatives.

1.2 Overview of STSE

The field of STSE education is broad. Situating science within the social, political and ethical context of the learner, its aims are two fold: a) To engage learners who are disengaged or disinterested in academic science by presenting it to them in an appealing context, b) To promote the democratic goal of science education, imparting skills to learners to engage with issues that they would have to face as citizens, to which they will need to apply considerations other than science. These two goals are different in their purpose. While the former does not question the content of science taught in school *per se*, concerning itself with issues of inclusion, the latter problematizes the science content taught in school and also engages with questions related to ethics, politics and values. The STSE movement in science education arose in response to movements world over in the 1960s and 70s – such as the environmental, pacifist and health movements which have placed academic science under scrutiny, raising critical questions on its impact and accountability towards society at large. Aikenhead (2003) lays out the origins and concerns of the different curricula and programs that fall within the purview of STS education in the western world. Beginning in the 70s and 80s, prominent initiatives included those in UK (Science In Social Context (SISCON) and Science and Technology in Society (SATIS)), Canada (Science – A way of knowing), Netherlands (PLON project). Over the years, there has been a proliferation of several other innovative programs,

curricula and innovative books. STS concerns have also found their way to major policy documents in several countries.

Pedretti and Nazir (2011), identify six broad extant categories of STSE education with respect to their professed or implicit aims of science education, focus and strategies. These include currents based on design related concerns, historical concerns, logical reasoning, value related concerns, sociocultural and socioecojustice related concerns. While some of these strands aim at increasing the accessibility and appeal of science to diverse learners - presenting science as a human endeavor or using socioscientific issues (SSI) as contexts to learn scientific concepts or to apply science, other strands do not place the learning of science at a pedestal – instead, they explore dimensions such as values, worldviews, and the deployment of other forms of knowledge alongside scientific knowledge when negotiating SSIs. These strands involve critical approaches to science as well (For example, the socio-ecojustice framework).

1.2.1 Science and society in India

Understanding how STSE education took root and evolved in India calls upon examining the larger discourses on the role of science in society prevalent in postcolonial India. These discourses can be broadly categorized into three kinds. First, the science for modernization discourse or what Chadha (2005) refers to as the liberal progressivist position, which upholds the Nehruvian vision of Scientific Temper (Rampal, 1992). This discourse views science, technology and development as going hand in hand and places an important role on the exercise of a scientific attitude to solve social problems. Second, the science for liberation argument or what Chadha (2005) refers to as the leftist position which are held by those who have been part of the People's Science Movement (PSM). The leftists, like the liberal progressivists, view science as an emancipatory tool that can bring about social change (Varma, 2001). However, they view it as elitist and inaccessible to the masses. Finally, there is the Science as violence argument or what Chadha refers to as the radical postcolonial view, advanced by those who Abrol (2014) refers to as Neo-Gandhians. They view the nexus of science–state–development – as against the ideals of justice and equity (Nandy, 1988, Rajan, 2005) and modern western science as hegemonic in the way it marginalizes other forms of knowledge. The dominant understanding of science and its relationship to society that has

captured public imagination in India is the one of the scientific temper advocates, the liberal progressivist view (Chadha, 2005). As I will elaborate later, it is this view that gets reflected in the science education discourse in the curriculum documents.

Notwithstanding the ideological power of science as a powerful, modernizing force in Indian society, the relationship between science and the public has been far from conflict-free. Movements against science and technology related development have been mounted all along in the Indian context. For instance, the struggle against the Sardar Sarovar Dam, the women's health movement in the 90's that targeted dangerous reproductive technologies (Manorama & Shah, 1996), the Chipko Movement, and the anti-nuclear energy protests at *Kudankulam* have raised critical questions on science and technology (Abraham & Rajadhyaksha, 2015; Varughese, 2012).

It also needs to be taken into consideration, when looking at the science-society interface, what notion of a "public" we refer to when we talk of the public engagement of science. Rudolph (2005) as well as Levinson (2010) point out that the public do not constitute a homogeneous category. In Rudolph's words, "It includes those individuals who are not immediate stakeholders on a given issue, those without organized lobbies to represent them, and especially those who are least advantaged in society" (p. 814). Along these lines, in the Indian context, Varughese (2012) identifies three groups of publics who engage with scientific controversies: the scientific citizen public, who constitute the educated, civil society members who are able to participate in decision making in science-society issues, the quasi publics, who include those who are uneducated, disempowered and systematically excluded from decision making on these issues and finally, the non-publics, who include the victims of scientific and technology developments, who have been physically harmed by these projects.

1.2.2 STSE education in the Indian context

In the Indian context, at the school level, the need to include STSE concerns in the science curriculum up to class X has been recognized by the National Curriculum Framework (2005). However, there is less clarity on how and in what manner this should be done (Raveendran & Chunawala, 2013). There has also been a history of out of school/non-formal educational initiatives that have tried to bring in these concerns in to the school. One such initiative is the

Kerala Shastra Sahitya Parishad (KSSP), an organization that is considered the forerunner of the people's science movements in the country, which, in the early 1960s undertook the mission of taking science to the people. Their agendas included popularizing science through the vernacular language, confronting superstitions, advocacy on health and environment, and critiquing the “big” development projects of the state, in which S&T have been implicated (Kannan, 1990; Pattnaik & Sahoo, 2012). The movement expanded and organizations like the Bharat Gyan Vigyan Samiti (BGVS) and subsequently, the All India People Science Network (AIPSN) in the late 80s promoted STSE concerns in their agendas. Innovative school science initiatives like the Hoshangabad Science Teaching Program (HSTP) in 1972 have also taken up science and society themes in their curricula (Rampal, 1992). Besides these, there have been several initiatives at higher education levels which have aimed at incorporating social and historical perspectives on science into the science curriculum. Raina, Pattanayak and Valte (2009) review these courses extensively. The aims of these courses and the debates regarding introduction of STS in higher education are reviewed in detail in chapter 6.

In the 1990s, an alternative curriculum centering STSE concerns was also developed by the Homi Bhabha Centre for Science Education, a national center devoted to research in science and mathematics education (Natarajan, 1999). Referred to as the 'Activity Based Foundation Curriculum' on science, technology and society, it was devoted to developing 'good citizenship qualities' in students of grade 11 and 12. In 2003-2004, another project with an STSE focus was also instituted, referred to as the Health & Environment: Action based learning programme (Mahajan, Bellara & Nair, 2005) involving undergraduate students, which had a focus on inculcating awareness of the interactions between health and environment.

1.3 The socioscientific issues (SSI) movement

Having discussed an overview of STSE as a field with specific reference to the Indian context, I now turn to a discussion of the socioscientific issues movement in science education, which is of concern for this thesis. The SSI movement emerged in response to the perceived limitations of the STSE approaches, which were seen as diffuse and theoretically under-evolved (Zeidler, Sadler, Simmons, & Howes, 2005). SSIs are “social dilemmas with

conceptual or technological links to science" (Sadler, 2004). These are typically ill-structured, real world issues that are controversial in nature. The need to introduce SSI in the school and undergraduate curricula has been recognized by the international science education community as well as national curriculum documents in several countries (Zeidler & Keefer, 2003; Hughes, 2000). Plenty of research is underway that delineates concerns that students raise in their negotiation of socioscientific issues.

That said, It is important to keep in mind that there exist different epistemological frameworks of understanding the science-society interface, which in turn inform how different researchers understand the issue of negotiation of SSI. Levinson (2007) discusses these frameworks on the basis of how technocratic they are. Technocratic frameworks of understanding the science-society interface stress the importance of canonical scientific knowledge in negotiating the issue and see scientific experts as solely capable of arbitrating on it. In non-technocratic frameworks of science-society interface, the central role of science in resolving the controversy is not privileged and the science needed to negotiate the issue is seen as tentative and uncertain. Scientific knowledge may also be critiqued and challenged in this model. Sources of knowledge that may be employed to negotiate the issue are seen to emerge from the needs of the participant, are multidisciplinary and may involve anecdotal evidence and local knowledge. Figure 1.1 depicts the classical, technocratic model of science-technology-society relationship with science at the core, and technology and society forming the outer layers. Scientific knowledge flows outward, through its *application i*n technology, which is in turn is *received* by society. Levinson (2007, 2010) argues hat this model has been challenged, with less technocratic models proposing porosity of the boundaries, through which knowledge flows back and forth. In the empirical work reported in this thesis, a non-technocratic approach to the science-society interface is employed.

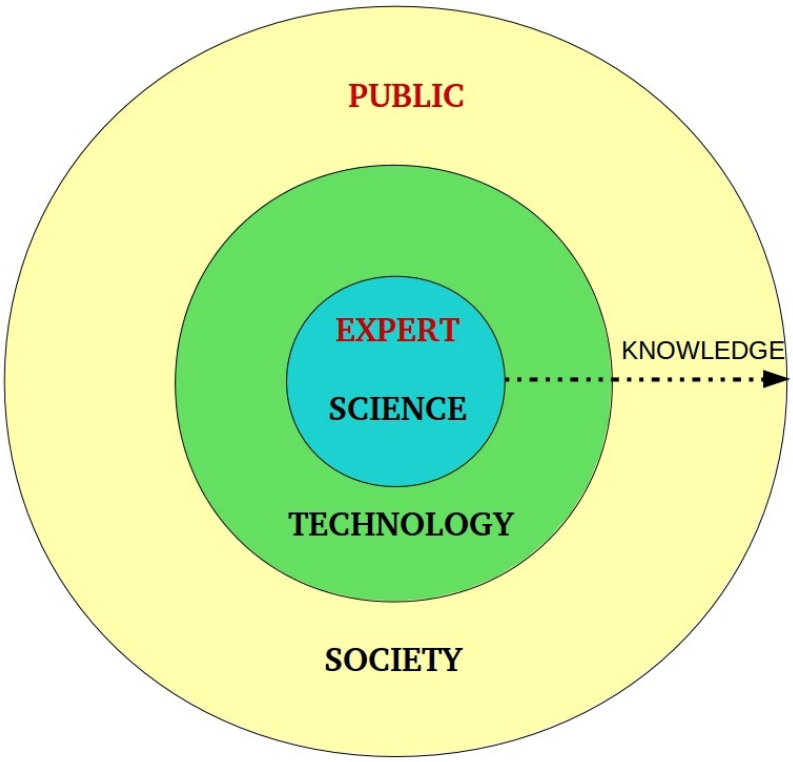

Figure 1.1 Classical model of science-society interaction
(derived from Levinson, 2007)

Adhering to a non-technocratic framework of understanding the science-society interface does not automatically translate to a rejection of science. To be sure, science has to its credit an impressive array of methods, tested and refined over the past few centuries. However, there is also a certain image of science that exists in the popular imagination and propagated through the textbooks that portrays the nature of knowledge as insular, value free and authoritative (Rudolph, 2005). This image of science has consequences in the way the public receives it - there is an unquestioned reliance and lack of criticality in their evaluation of scientific developments. Lack of understanding of the nature and limits of scientific knowledge also makes experts non-responsive to the needs of the public.

1.4 Science, value-freedom and objectivity: Perspectives from philosophy of science and science studies

There is a wealth of philosophical literature that looks at the nature and purposes of scientific knowledge from the perspective of its role in society (Allchin, 1999; Kitcher, 2003; Longino, 1983, 1987, 2006; Rudolph, 2005). I employ these to argue that creating a dichotomy between STSE topics and academic science content in terms of viewing the former as value-laden and the latter as value-free reinforces the "myth of purity" of academic science. Engaging with the contentious philosophical aspects of the academic science content along with a discussion of topics that fall within the STSE category is necessary for students who are training to be scientists in order to be more humble and reflexive with regard to the knowledge that they produce. Likewise, those students who are not training to be scientists also stand to gain from understanding the nature and limits of scientific knowledge. Next, I review perspectives from philosophy of science and science studies that discuss science's relationship with society. The essence of this thesis is infused by these perspectives.

1.4.1 Values in science

Howard (2009) posits that "science in a social context is influenced by values, motives, social interests, and political agendas" (p.202). In fact, the fact-value dichotomy maintained even in the so-called pure sciences have been questioned[2] (Laudan, 1984; Mc Mullin, 1983; Putnam, 2002). These views have been succinctly summarized by Allchin (1999). Pointing out that the fact-value dichotomy is not as sacrosanct as popular conceptions regard it, he reviews literature in philosophy and sociology of science which discusses the relationship between science and values, identifying three broad ways in which they interact. First, there are values of science which are values internal to science or epistemic values – what scientists regard as necessary values when engaging in scientific inquiry – such as novelty, accuracy, simplicity, precision, repeatability, paying heed to research ethics and keeping at bay error, fraud and so on. Second, values from larger culture enter science through individual practitioners, as elucidated by feminist philosophers of science who have exposed androcentric values inherent

2 A major proponent of the fact-value dichotomy was David Hume, who stressed that statements pertaining to what *is*, or those which are matters of fact need to be seen as different statements that refer to what *ought* to be, or which are statements of value (Reiss, 1999).

in different areas of scientific research.[3]

Finally, Allchin points out that values from science – both as a product and process get exported to society. By this, he refers to those values regarding science that are held by society or the public at large – that it is objective and hence scientific evidence qualifies as the final arbitrator of any socioscientific controversy. He cautions against this conception and discusses how, in risk assessment particularly, where scientific evidence is uncertain, values other than science may be employed when negotiating the issue. He also discusses briefly the intersection between new technology and values, pointing out that new technology can either raise new values (here, he discusses the example of organ transplants, pointing out that though they help us in preserving the value of life, they also raise new values on equitable access) or radically challenge fundamental values (Here, he discusses the example of new reproductive technologies and how they conflate the concept of parentage).

These insights from philosophy of science point to the myriad ways in which science, technology and values intersect and constitute the bedrock of the theoretical standpoint that the thesis adopts in its critique of the science curriculum documents and textbook as well as students negotiation of socioscientific issues.

1.4.2 Feminist critiques of science and technology

The feminist critiques of science and technology have been instrumental, as pointed out in the earlier section, in uncovering androcentric values in scientific theories, raising larger questions on the fact–value dichotomy. Referring to the work of feminist philosophers of science, Mayberry (1998) notes:

> Feminist approaches to science education can serve dual, although related and complementary, purposes. As feminist scientists begin to raise important questions about Western science (e.g. Who benefits and who does not from the uses to

3 Helen Longino (1987), for instance, when discussing the role of values in science, extends the implications of the under-determination thesis put forth by Quine. She posits that if a theory is under-determined by data, and the correspondence between theory and data is not logical or straightforward, then it makes it possible for social and cultural values to play a role in theory construction. This, she cautions does not entail an embrace of relativism as there are mechanisms that exist that could help guard against bias by ensuring that a plurality of standpoints or values get represented and subsequently, they should check and balance each other.

> which science is put? What role does the historically specific context within which conventional science has developed and flourished play in constituting content, practice, and use in the natural sciences? What are the specific ideologies and values that are carried into scientific research? How has modern science sustained hegemonic structures and distributed benefits to some groups and cultures while ignoring or exploiting others?) and begin to create sciences that speak from the lives of women and other marginalized groups, not only will existing systems of science be challenged, but women's interest (as well as other marginalized groups' interests) in the sciences will arise (Harding, 1993). Consequently, not only will the face of the scientific community become more multicultural and gender, race, and class inclusive, but members of the community will be part of an enterprise that now encourages (rather than discourages) its members to become actively involved in asking new questions from fresh standpoints. New theories, methods of investigation, and practices will be created that fundamentally alter descriptions and explanations of the natural world and question who benefits from the uses to which science is put (Harding, 1989). (p. 452)

Further, she points out that an integrated feminist science education aims at a) representing science as contextualized, placing it within the social, political context and b) developing criticality and commitment to social justice and transformation. This is consistent with the goal of critical scientific literacy advocates discussed above. As Shah (2012) notes, the shift to feminist science education,

> … will result in a more informed public that benefits from understanding the nuances and complexities of science and a more sensitized scientific community that takes this discipline to newer depths while recognizing the limits and possibilities of partial visions instead of supposedly enlightened certainties. (p. 168)

It will become apparent to any reader of this thesis that the analysis of textbook and curriculum as well as the analytical approaches employed when analyzing socioscientific issues have been influenced by feminist literature in science education (Brotman & Moore,

2008; Mayberry, 1998) and the feminist critiques of science and technology (Longino, 1983, 1987; Manorama and Shah, 1996; Martin, 1991; Narayanan, 2011; Qadeer, 2009, 2010; Shah, 2009).

1.4.3 Changing institutional configuration of science and nature of science

Late modernity has brought about a change in organization of science. Academic science, that was largely confined to the laboratories, occurring within universities is slowing being replaced by a new kind of science that defies the conventional Mertonian norms and involves various new actors. Scholars have theorized these reconfigurations as post-academic (Ziman, 2000), post normal (Funtowicz and Ravetz, 1993) and Mode 2 science (Nowotny, Scott & Gibbons, 1994). Though there are subtle differences between these models, they agree that the new science has become embedded in the context of application and is driven by industrial and governmental needs. This shift is evident in new technoscientific disciplines such as Genomics, Robotics, Artificial intelligence and Nanotechnology. Modern day technoscience marks a transformation from "Enlightenment science – value-free, objective and impersonal – to one imbued with values, diverse subjectivities and integrating multi-party perspectives." (Levinson, 2010, p.77). Put differently, the traditional dichotomy between representing and intervening is breaking, and the new knowledge which is *actionable* in nature demands ethical evaluation (Basu, 2015). There is thus a necessity for new approaches to examine reality; perhaps involving a synthesis of approaches from the natural sciences and human sciences. As I argue in chapter 6, science education will need to take on this challenge in higher education.

1.4.4 Instrumentalism, embodied cognition and science education

Pragmatic scholarship in philosophy of science and embodied cognition also questions notions of whether science faithfully represents reality and more importantly, what larger motives guide theory building in science. Some science educators committed to opening up science and science education to public scrutiny and democratic participation have been emphasizing the importance of reclaiming the philosophy of science of John Dewey (Levinson, 2010; Rudolph, 2005). For Dewey, thought or the mind helps an organism respond to and change its environmental conditions through actions. Actions are primary means by which organisms interact with the world and the primary role of thought is to facilitate this.

Further, an idea, even before an action has ensued, can change the world, because a new set of potentialities for action have been created. Extending this idea to scientific ideas and concepts, Dewey viewed the primary purpose of science as having to do with interconnections and the importance of scientific concepts in facilitating our dealings with things directly experienced (Godfrey-Smith, 2002). Rudolph (2005) puts this more clearly:

> Knowledge would come to be seen as part of a recursive process where human needs provide the context for the development of intellectual tools that not only meet the needs for which they were created, but also lead to understandings of the world that open up new possibilities for reflective action. (p.816)

Recent work in embodied cognition that discusses intentionality in perception also converges on this idea when it stresses that perception is active and that the organism needs to exercise its skills in specific ways to shape the flow of matter and energy. A primary way by which perception is linked to thought is through language and it is important to pay careful attention to it as it helps in visualizing and being in this world. Language changes over time and is closely linked to the prevalent social context. Knowledge of the world, therefore, has an important linguistic element which adds to its value-ladenness and contingency. These ideas have been reviewed in Colucci-Gray, Perazzone, Dodman and Camino (2013).

1.5 Personal journey

Consistent with feminist research methodology (Westmarland, 2001), where acknowledging one's own location and subjectivity is important when theorizing about the field, I think it might be appropriate to disclose the motivations for why I undertook this research as well as the approaches described in this introductory chapter in terms of my personal journey. I have a training in biological sciences and after obtaining a Masters' degree in Biotechnology, I decided to change fields. There were several reasons for doing so. Firstly, a certain kind of disillusionment had set in, about engaging in mundane laboratory work. The science that I was exposed to, in the molecular biology laboratories that I had interned in, did not appeal to me. Very often, I felt as though I was following procedures (solving puzzles in the Kuhnian sense) without really gaining a perspective on how the work I was doing was contributing to larger ideas or theories – I felt like an easily replaceable cog in the wheel. Secondly, I felt I

lacked a perspective on the science that I was doing and felt that reading or studying the philosophy of science might help. Thirdly, I had started to become conscious of how science was working as an institution. The laboratories where I interned as an undergraduate and postgraduate student were politics ridden and highly competitive, with cases of internal conflict between scientists. In these spaces, fraudulent practices were often committed to obtain quick results, and sexism was rampant towards young women scientists. Besides this, in my final year of Masters, I had undertaken an assignment on the Biopharmaceutical industry as part of the final semester industrial biotechnology course. During the course of researching for this assignment, I came across media articles that brought to light gross ethical violations on the part of multinational companies that outsource clinical trials to third world countries like India, where uneducated, poor women are often used as guinea pigs, without their consent. This opened my eyes to the fact that science and technology as institutions are not immune to the larger socio-political context within which it is embedded. Following this, enrolling for a PhD in science education and more specifically, exposure to courses in philosophy of science, feminist science studies and science and technology studies have helped me consolidate the experiences I had as a student of science and examine them critically.

Synthesizing my personal experiences as well as my engagement with the philosophical positions discussed in this chapter, I think it is important to lay out what my standpoint towards science education is, as I view science and science education as value-laden enterprises and my ideological position as a researcher as having influenced the manner in which I have conducted my research. As a feminist, critical science educator I aim to bring into science education a sensitivity to the historical, cultural and political embeddedness of science, a knowledge system that is marked by the standpoints of its practitioners. This in turn makes me wary of adopting a taken for granted understanding of science, as a finished intellectual product. My interest lies in what is getting constructed as science in science education research and the politics that surround this process. However, this does not entail a rejection of science, or an embrace of relativism, but a view consistent with what Shah and Chadha (2011) call a “critical, reflexive and empathetic approach” to science education at all levels.

1.6 Focus of the thesis

Bringing it all together, I would like to point out that this thesis is primarily an exposition of an alternative view of what a science education that aims to inculcate critical perspectives on science and social justice concerns could be. In accordance with this vision, I report three studies in this thesis. Study 1 (reported in chapters 2 and 3) examined the school science curriculum documents, and the higher secondary class XII biology textbook with a focus on how it approaches the fact-value dichotomy. Study 2 (reported in chapters 4 and 5) involved empirical investigations with higher secondary students with a focus on the value considerations (epistemic and non-epistemic) that students bring to bear on a socio-scientific issue related to commercial surrogacy. In chapter 6, I argue that critical science education should persist through to the PhD level and briefly report findings of a study (study 3) involving PhD students, where the epistemic and non-epistemic criteria that students generate while evaluating genetic determinism are explored. The thesis does not compare any of the reported studies, but, a) Points out that the manner in which social, political and ethical concerns are discussed in the existing school science curriculum leaves a lot to be desired, b) Demonstrates ways in which educational experiences could be designed that expose students to the interaction between science and values in context, and c) Advocate a vision for critical science education at all educational levels.

CHAPTER 2

ETHICOPOLITICAL CONCERNS IN THE SCIENCE CURRICULUM DOCUMENTS AND HIGHER SECONDARY BIOLOGY TEXTBOOK

2.1 Introduction

There are several initiatives in science education that have tried to engage with the issue of values[4] in science and how to bring an awareness of these concerns into the science curriculum. The STS movement in science education (Aikenhead, 2005), for instance, seeks to teach science and technology by placing them in the larger social, political and ethical context. Unlike many science curricula worldwide that have emphasized STS education, the Indian science curriculum is yet to embrace these concerns in a major way (Raveendran & Chunawala, 2013). This chapter will report an analysis of school science curriculum documents (NCERT, 2006b; 2006c) as well as the class XII biology textbook (NCERT, 2006a) with a focus on how these present social, political and ethical concerns. The higher secondary science curriculum represents a level where disciplinary pressures operate, so it becomes interesting to analyze how STS concerns get treated by the curriculum and textbooks at this level. Can these concerns be omitted from the curriculum? Is a value-free rendering of scientific and technological applications possible? These concerns brought me to analyze the higher secondary biology textbook.

Textbooks are an important pedagogical resource in the teaching and learning of any discipline. This is particularly true for Indian classrooms where they are prescribed by the state (Kumar, 1986; Vijaysimha, 2013). Therefore, it becomes all the more important to recognize that textbooks are not neutral with regard to the knowledge that they select and

4 The term “value” is used to denote notions pertaining to “what ought to be” and could also include epistemic values. In this chapter, however, I use the term value to denote ethicopolitical concerns.

present – certain dominant values and ideologies get selectively and authoritatively transmitted through them (Apple, 1990). Apple (1992) argues that meanings of a text are multiple and are not necessarily contained within it. Readers construct their own meanings of the text which are in turn influenced by their social locations. He further discusses different ways in which people interpret a text: dominant, negotiated and oppositional. In a dominant reading of a text, the reader largely accepts the message of the text at face value, while in a negotiated reading, the reader may not agree with particular claims but accepts the overall tendencies of the text. In an oppositional response to the text, the reader "repositions herself or himself in relation to the text and takes on the position of the oppressed" (p.10).

Science textbooks are often considered "the site where each new generation of citizens and scientists learn to practice their trade" (Kuhn, 1996) and they have a peculiar power associated with them because of the sense they give of speaking the truth objectively (Bazzul, 2013). Therefore, it becomes difficult to challenge the taken for granted "truths" conveyed in science textbooks, even when they are about human affairs. Bazzul (2013) succinctly expresses what it means to critically engage with science textbook discourse:

> Critical examination of scientific discourse endeavors to expose knowledge, assumptions, values, and viewpoints whose political and historical 'character' has been eroded and/or passed off as something 'natural'. (p.13)

This entails the need to problematize the *naturalness* and the assumed objectivity of science textbook discourse (Bazzul, 2013). There has been some research in different parts of the world on how social and political values have been incorporated in biology textbooks. Many of these studies have focused on the representation of STS issues and concerns in the biology curriculum. A prominent study in this area is that of Rosenthal (1984) which revealed that between 1960 and 1980 there was a decline in the emphasis of STS topics in US biology textbooks. The study also reported that there was hardly any treatment of the contentious aspects related to these topics. Later studies by Chiang-Soong & Yager (1993) and Chiapetta, Sethna & Fillman (1993) also revealed that very few STS topics have been incorporated and discussed in the US biology textbooks that they analyzed. It was also observed that the emphasis on these topics decreased as grade level increased (Chiang-Soong & Yager, 1993).

Similar results were observed by Irez (2009) in a study of secondary biology textbooks in Turkey where science-society aspects were neglected.

Most of these studies have used some criteria on the basis of which they have identified STS issues. Arriving at these criteria, however is not straightforward. Rosenthal (1984), for instance, points out the difficulty in identifying social issues in biology textbooks. As posited by her, “biological and social systems are interrelated and the interactions between biological and social systems are complex. This makes it difficult to establish clear, independent distinctions.(p.821)” She illustrates this point using the example of birth control which could either be introduced as part of human reproduction or population control. The “context”, she points out, needs to be taken into account to decide whether birth control should be treated as a social issue or not. This is a reasonable point if one is only interested in analyzing questions of *representation* of STS. However, if we understand facts and values as essentially enmeshed with each other, it becomes difficult to delineate boundaries between academic science content and STS topics. Nevertheless, I concede that some topics are more obviously value-laden than others.

In this chapter, I undertake an ideological analysis of certain topics in the textbook with a focus on:

a) What gets omitted: As Hodson (2003 p.654) argues, “values can be promoted as much by what is omitted from discussion as by what is included”. Therefore, an analysis of the textbook explores omissions of the social or political: silences on some matters is as much part of the analysis as what gets discussed on these matters.

b) What gets selected: The taken for granted scientific content is also critiqued along side the social and political content.

We observe this kind of analysis in the studies of Snyder and Broadway (2004) and Bazzul (2011) where they examined biology textbooks for heteronormativity as well as Ninnes (2002) who examined the manner in which indigenous knowledge is represented in the earth science curricula of various countries. This kind of work commands rigorous engagement with critical debates in social sciences and humanities that would inform these topics.

2.2 Theoretical perspective

The analysis that has been done would fall within the tradition of critical discourse analysis (Fairclough, 1989), which predicates itself on the understanding that language is a social activity, where it is viewed not just as mirroring the larger social structure, but as something that actually impacts wider social structures. Fairclough introduces a methodology to examine texts in terms of vocabulary, grammar and textual structures. The analysis will pay attention to these aspects as well, wherever they are apparent, highlighting words and phrases in the text that suggest adherence to discourse types that reflect certain undercutting ideologies. I will also contest these ideological standpoints from alternative ideological positions. The validity of my reading is open to the reader to judge based on the force of my counterarguments, and the kind of evidence I bring to bear on my arguments.

The predominant theme of the class XII biology textbook (NCERT, 2006a) is “Biology for human welfare” with a focus on technology and applications in the textbook. I will examine what the textbook explicitly brackets out as value concerns – ethical and political concerns as well as implicit values in topics that fall at the interface of the scientific and social worlds – human life and its regulation as well as the relationship of humans with the non-human world.

Bazzul (2013), in his study of Canadian biology high school textbooks notes: “discourse in these books... is always a confluence of both forces for change and those that maintain the status quo and oppressive conditions” (p.144). In the analysis laid out below, I observe a similar confluence of such forces in the higher secondary biology textbook. While the textbook often upholds regressive patriarchal, anti-egalitarian ideologies of the state; it also, at the same time, reflects forces for change. Before I turn to a detailed examination of the textbook, I will first discuss what the the position paper on the teaching of science's (NCERT, 2006b) understanding of the nature of science and scientific literacy as it is a vision document for school science education in India.

2.3 The fact-value distinction in the position paper on the teaching of science

The National Curriculum Framework (2005) informed by the National focus group's position paper on the Teaching of Science (NCERT, 2006b) provided recommendations for textbook writing, both at the national and state level. The position paper begins with an explanation of the nature of science and technology. It defines science as a “dynamic, expanding body of knowledge covering ever new domains of experience' and states that 'a scientific theory, to be acceptable, must be verified by relevant observations and/or experiments” (NCERT, 2006b, p.11). It makes a distinction between science and technology, describing science as “open ended” (with regard to its method) and “universal” and technology as “goal oriented” and “local specific”.

The overall perspective of the position paper on the nature of science is positivist, though there is some acknowledgement of the post-positivist critiques of science. For instance, there is reference to what constitutes the 'methods' of science and an attempt to clarify that these do not constitute a standard cookbook recipe sequence as well as an emphasis on the laws of science not being “fixed, eternal truths”. There is also a reference to the sociological critiques that challenge the “professed value neutrality and objectivity” of science. However, this is not elaborated upon, giving the impression that only lip service is being paid to these perspectives as there are other definitive statements to the effect that facts are at the core of science. On the issue of science and its relationship to society the position paper states:

> 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 possible aberrations and misuse of science can be checked by the people themselves. *Science, tempered with wisdom, is the surest and the only way to human welfare*. This conviction provides the basic rationale for science education (NCERT, 2006b, p.2, emphases added).

Here, the words “surest” and “only” are collocated with “way” to convey a scientistic notion of science as an emancipatory ideological force. If science is used with wisdom, it is the “only way” to human welfare. This notion resonates with the Nehruvian vision[5] of scientific temper which considers science as the only path to development, suggesting a technocratic view of the science-society interface with science being the sole arbitrator of social problems such as poverty. The public discourse of science in India, according to Chadha (2005), upholds a scientistic notion of science as the truest and most superior mode of knowledge, marginalizing other modes of knowing and equating criticality and progress to 'scientific temper'. According to this view, the problems associated with science lie with its abuse by society while its epistemological core is seen as pure and uncontaminated.

On its vision for science education, the position paper reiterates that facts are at the core of science and that emphasis should be on the learning of products and process of science as propagated by this statement:

> Facts, principles, theories and their applications to understand various phenomena *are* at the core of science and the science curriculum *must obviously* engage the learner with them appropriately (NCERT, 2006b, p.12, emphasis added).

Fairclough (1989) uses the term modality to refer to the authority with which a speaker or writer expresses themselves. In his words, “if it is a matter of the speaker or writer's authority with respect to the truth or probability of a representation of reality” it is called expressive modality. In the aforementioned quote, the employment of the simple present tense “are”, confers a sense of definitiveness to the statement. The employment of the word “obviously” also conveys a sense of absolutism, leaving the reader with no choice but to accept that science education should deal with the transaction of facts and concepts alone. According to the position paper, the 'general aims of science education' should be understood in terms of six validities – cognitive, content, process, historical, environmental and ethical validities (Appendix I). Although a hierarchy in the validities is not stated, it is clear that the core emphasis is on the content and process validities of science. This is suggested in the very ordering of the validities and by the previously quoted statement that emphasizes facts and

5 The Nehruvian vision of science views science as the ideology that can free modern India from poverty, superstition and intractable problems like population (Arnold, 2013)

principles as being at the core of science. Also, the idea of distinct and separate content validity (with its emphasis on factually correct content), environmental validity and historical validity (which emphasizes the need to *place* science in the learners' environment and the need to communicate how "social factors influence the development of science") serve to re-emphasize the fact-value dichotomy by segregating the scientific from the social and political. This framework of understanding the aims of science education in terms of distinct and separate 'validities' is hence problematic.

The position paper also prescribes what should constitute the science curriculum at various levels. For the higher secondary level, it emphasized a focus on disciplinary knowledge: "The curriculum at this stage should be disciplinary in its approach, with appropriate rigour and depth" ... "there should be strong emphasis on experiments, technology, and investigative projects" (NCERT, 2006b, p.16).

In addition, STS education at the higher secondary level is accorded an extracurricular status. The tone is definitive:

> Students should be encouraged to participate in debates and discussions on issues at the interface of science, technology and society. Though these would form an important part of the learning process, they *should not* be included for formal assessment (NCERT, 2006c, p.16, emphasis added).

Note the use of the modal auxiliary verb "should not" to convey authority when pointing out that socioscientific issues ought not be provided a space in the formal curriculum. In sum, I find that the position paper gives primacy to facts over values as evident in the positivist understanding of the nature of science, the view that science can alleviate all social problems and the vision for scientific literacy that emphasizes learning of facts, principles and theories.

2.4 The higher secondary biology syllabus

To get a sense of how the writers of the syllabus interpreted the position paper I also explore the space afforded to ethicopolitical concerns in the syllabus document (NCERT, 2006c). The syllabus document is important to analyze because it informs textbook writing. Like the position paper, it too gives primacy to concepts and principles of science. This is evident in

the statement which refers to the “primary aim” of the biology curriculum at this stage as being to emphasize “the underlying *principles* that are common to both animals and plants, as well as highlighting the interrelationships of Biology with other areas of knowledge” (p.1, emphasis added).

Further, the syllabus document endorses the need to study applications of the discipline of biology when it refers to the need to communicate “the connection of the study of Biology to real life problems – use of biological discoveries/innovations in everyday life – in environment, industry, medicine, health and agriculture” (NCERT, 2006c, p. 1).

An interesting difference from the position paper, however is the fact that the syllabus document prescribes the need to include some topics which has 'relevance from the societal point of view' and 'ethical issues':

> The syllabus *also* takes up issues pertaining to environment, health and other ethical issues that arise with any interference of human beings in the natural processes, which have great relevance from the societal point of view. A discussion on these in the prescribed syllabus would help tackle prevalent misconceptions and empower the student to play a rational, responsible and informed role in society (NCERT, 2006c, p.1, emphasis added).

In the aforementioned quote, one may perceive an add-on status ascribed to ethical issues effected through the employment of the adverb “also” implying a dichotomy between facts and values.

2.5 Class XII biology textbook

The NCERT higher secondary biology curriculum comprises two textbooks: class XI and class XII. The Class XI textbook deals completely with concepts and principles in biology while some portions of the class XII textbook deals with applications.

According to the preface of the class XII biology textbook, the primary aim of teaching biology to students is to nurture interest in biological phenomena and concepts as well as to emphasize its interconnections with other areas of knowledge. The class XII textbook delineates biological concepts from technological applications. This is evident in the preface

of the class XII textbook where there is a discussion of the nature of biology and its *applications* to human welfare. The chapters which discuss reproductive principles in different organisms (reproduction in lower organisms, plants and humans), genetics and evolution as well as principles of ecology introduce students to concepts and principles in modern biology while the discussion of applications occur in the chapter on reproductive health, the unit on biology in human welfare (which comprises three chapters: Human health and disease, strategies for enhancement in food production, microbes in human welfare), biotechnology and the chapter on environmental issues. Table 2.1 is a break up of the different units in the textbook and their primary focus:

The overarching position of the textbook regarding biology and its role in human life are exemplified in the following excerpts:

> ... Ever since the days of Rene Descartes, the French philosopher, mathematician and biologist of seventeenth century, *all* human knowledge especially natural sciences were directed to develop technologies which add the *creature comforts* to *human lives*, as also to add *value to human life*. The whole approach to understanding natural phenomena became *anthropocentric*. Physics and chemistry gave rise to engineering, technologies and industries which *all* worked for *human comfort and welfare*. The *major utility* of the biological world is as a source of food. Biotechnology, the twentieth century off-shoot of modern biology, *changed* our daily life as its products *brought qualitative improvement* in health and food production." (NCERT, 2006a, Biotechnology, p.191, emphasis added).

> ...Physics and chemistry dominated public perception of science for a long time. Day-to-day life of *man* was influenced by developments in physics, chemistry and their respective manufacturing industries. Slowly and steadily, biology, not to be left behind, *demonstrated* its utility for human welfare. Medical practice, especially diagnostics, green revolution and the newly emerging biotechnology and its *success stories* made the presence of biology felt by the common man. Patent laws brought biology into political domain and *commercial value* of biology *became obvious*. (NCERT 2006a, p.V, emphases added)

Table 2.1 Chapter-wise focus of class XII biology textbook

Unit/Chapter	Title	Focus
Unit VI	Reproduction	
Chapter 1	Reproduction in Organisms	Concepts and Principles
Chapter 2	Sexual Reproduction in flowering plants	Concepts and Principles
Chapter 3	Human Reproduction	Concepts and Principles
Chapter 4	Reproductive Health	Applications
Unit VII	Genetics and Evolution	
Chapter 5	Principles of Inheritance and Variation	Concepts and Principles
Chapter 6	Molecular Basis of inheritance	Concepts and Principles and some applications (Human Genome Project)
Chapter 7	Evolution	Concepts and Principles
Unit VIII	Biology in Human Welfare	
Chapter 8	Human Health and Disease	Concepts and Principles
Chapter 9	Strategies for enhancement in food production	Applications
Chapter 10	Microbes in Human welfare	Applications
Unit IX	Biotechnology	
Chapter 11	Biotechnology: Principles and Processes	Concepts and Principles
Chapter 12	Biotechnology and its Applications	Applications
Unit X	Ecology	
Chapter 13	Organisms and Populations	Concepts
Chapter 14	Ecosystem	Concepts
Chapter 15	Biodiversity and Conservation	Concepts
Chapter 16	Environmental Issues	Applications

A prominent theme in the class XII biology textbook, as the excerpts provided above suggest, is biology in human welfare. This has primarily to do with the technological applications of biology. In the first excerpt, through the employment of specific vocabulary and grammatical inflections, it is established that the thrust of natural sciences has swayed towards the utilitarian, anthropocentric goal of bettering human lives. One particular device that is being

used here is over-wording (Fairclough, 1989), where establishment of a certain kind of reality occurs through the overuse of words or synonymous words. In the first paragraph, the emphasis on the role of biology in betterment of human life gets established through the use of words like “anthropocentrism”, “creature comforts”, “utility”, “add value”, “qualitative improvement”. These are employed to convey an uncritically positive view of technologies and industries which use the knowledge generated by the natural sciences. Similarly, in the second excerpt, we find the deployment of definitive verbs and phrases to glorify technology – green revolution[6] as well as medical diagnostics and biotechnology – which are all mired in political controversy (Visvanathan & Parmar, 2002; Ghai and Johri, 2008; Shiva, 2005) – are referred to as “success stories”. The political controversies associated with these technologies are reduced to issues of “patent laws” and issues of intellectual ownership without any acknowledgement, whatsoever, of the conflicts around questions of access, safety and discrimination.

Is there any way by which we can understand the overriding optimism regarding these controversial technologies? Varughese (2012) in a discussion on technoscience, state and citizenship in post colonial India points out that “Although the post colonial state's engagement with science went through several ups and downs, the position of science as integral to the state continued even after the neoliberal restructuring of the state in the 1990s. The state protects technoscience from political interventions and helps safeguard its status as the epistemic engine of progress” (p.244). This has lead to the emergence of a technoscientific complex that feeds the developmentalist rhetoric of the state by offering sophisticated, hi-tech products and projects. This close alliance between state and technoscience absolves the latter of any need for social audit, protecting it from public scrutiny. In this scenario, Abraham & Rajadhyaksha (2015) point out, “Knowledge of the mechanical world–technoscience–replaces other forms of knowledge seeking to manage social issues” (p.4).

The technological society that came into being with Indian independence, albeit committed to enhancing human welfare, was characterized by authoritarianism and a tendency to devalue politics. According to Abraham & Rajadhyaksha (2015), the Indian state exerted disciplinary

6 The green revolution in India began in the 1960s with the introduction of modern agricultural technologies which included high yielding varieties of cereals, irrigation technologies as well as agrochemicals which include fertilizers and pesticides.

biopower by "working from a high modernist paradigm of transformation from above", rendering "the population as subjects fit at best for benevolent tutelage" (p.5). However, since independence, the people have mounted resistance against the top down development initiatives of the state which include dams, mining projects or setting up of nuclear power plants. Abraham & Rajadhyaksha also note that since liberalization of the Indian economy in the 90s, the involvement of the private sector (both domestic and foreign) in mega technoscientific development projects has increased and there have been struggles against these projects as well, though the extent of success of these resistance movements have been limited.

Turning to the developments within biological sciences, Rajan (2006) observes that the object, practice and locations of bioscience have changed over the previous four decades and that "one of the major directions of this change has been toward more corporate forms and contexts of research" (p.4). Consequently, bioscience, according to Rajan (2006), cannot be analyzed simply by studying it within the laboratories. Rather, it should be analyzed in terms of the larger social, economic and political context within which it is produced. In an analysis of biotechnology in India, Visvanathan and Parmar (2002) argue that biotechnology "was created within the politics of anxiety and desire in India" (p.2715): while it has the promise of addressing the larger issues of hunger and other survival related concerns, it has also attracted the criticisms of politically oriented intellectuals and grassroots groups inviting the wider debates on development and globalization.

The class XII biology textbook has an emphasis on biotechnology and for this reason it becomes interesting to analyze in terms of how it reflects the "politics of anxiety and desire" around these new technologies. Moreover, as pointed out earlier, there is also an acknowledgement in the syllabus document that the textbook deals with ethical issues that arise as a result of the "interference of human beings with natural processes" making it important to examine how these ethical issues are discussed.

In the light of the above discussion, in this chapter, I do two things: 1) Examine what the textbook *explicitly* brackets out as ethical and political concerns, 2) Examine *implicit* values conveyed in the topics that lie at the interface of the scientific and social – those that relate to

human life and its regulation, as well as the relationship of humans with non-human world[7]. More specifically, the topics analyzed include those related to human health, sexuality, population as well as biodiversity and environmental issues. Other topics could have been analyzed as well, but these were chosen because they are interdisciplinary in nature and scientific, ethical and political concerns intersect explicitly in the discussion of these topics. Besides this, ideological analysis of these topics in textbooks has already been undertaken (see Bazzul, 2013; Bazzul & Sykes, 2011; Snyder & Broadway, 2004).

I finally wind up with a discussion of how the textbook engages with the idea of risk. Viswanathan & Parmar (2004) note that the Indian democracy, like most parts of the developing world, is struggling to cope with the idea of risk[8]:

> Biotechnology as a scientific venture in the populist and technocratic imagination is alive and well but biotechnology as a part of the new democratic imagination committed to the rule of law and regulation, and governance sensitive to the ideas of risk is fragile (p.2724).

2.6 Explicit references to ethical, social and political concerns in the textbook

In several sections of the textbook, explicit references to social, ethical, political concerns exist. A keyword search conducted on variants of the word ethical, social and political reveal interesting patterns (Appendix II). According to the preface of the textbook, what brought biology into the "political domain" are patent laws: "Patent laws brought biology into political domain and commercial value of biology became obvious" (p.V). The sense that gets conveyed here is that the politics around biological knowledge and applications are confined to patent laws and issues of intellectual ownership whereas aspects such as safety, environmental and health related risks and access are not mentioned.

This tendency is further apparent in the discussion of "ethical issues" in the chapter on biotechnology (NCERT, 2006a, p.213, 214) and its applications. The section starts with a brief

7 Wherever possible, I attempt to provide excerpts from the textbook to support my analysis. Additional excerpts have also been included in the appendices (II, III, IV).

8 Their interviews of farmers on their experience of genetically modified BT Cotton reveal that most did not understand the nature of risk associated with GM technologies.

discussion on the inherent morality of interfering with the genetic make up of other non-human life forms as well as the impact of introducing these organisms into the ecosystem. This is quickly wound up with a mention of the Genetic Engineering Approval Committee (GEAC) which, according to the textbook has been set up to arbitrate on these matters. The major part of the discussion pertains to questions of intellectual ownership – biopiracy of traditional bioresources by multinational companies --and the consequent economic losses that the nation suffers on account of this. The discussion is important as it does bring to light the politics of multinational corporations of the first world and its exploitative relationship with the third world. Furthermore, the textbook also acknowledges the contribution of farmers and indigenous people in the development of the biological resources. However, the discussion is still limited as it is not on the issue of patenting and ownership of biological material *per se* (which is a hall mark of capitalist science and technology) as much as it is about who is pirating whose resources.

The following sentence is illustrative:

> ... if *we* are not vigilant and *we* do not immediately counter these patent applications, other countries/individuals may encash on *our* rich legacy and we may not be able to do anything about it. (NCERT, 2006a, p.214, emphases added)

In the above quote, the writer of the text establishes a sense of unity/solidarity with the readers, or what Fairclough (1989) refers to as relational modality, with the repeated use of the pronoun “we”. Further, the possessive pronoun “our” conveys a strong sense of ownership. The use of the metaphor “rich legacy” to refer to what is actually non-human life that serves some utilitarian purpose converts it into a thing or a resource.

This brings us to an important point that Visvanathan (2009) makes when discussing patenting and ownership of life:

> ... knowledge and information are flows. To treat them as stock violates the local sense of justice. Second, even if knowledge becomes stock, heritage, memory and legacy are still acts of trusteeship. They can only become parts of an intellectual commons. Third, patenting life violates the sacredness of life, the connectedness of life. To patent life is to be anti-ecolate.

The chapter “Biodiversity and Conservation” (chapter 15) also puts forth an *ethical argument* for conserving biodiversity. This is taken up for discussion in the section on Non-human world.

2.7 Implicit values conveyed through the textbook

In the sections that follow, I discuss specific topics through which certain implicit values are conveyed (Also, refer to Appendix III). These include health, population, sexuality and the non-human world.

2.7.1 Health

Two chapters in the textbook discuss the topic of health. While one chapter discusses health and diseases at a more broader level (chapter 8), the focus of the second is on reproductive health (chapter 4). Health is defined by the textbook in the following manner:

> The term health is very frequently used by everybody. How do we define it? Health does not simply mean ‘absence of disease’ or ‘physical fitness’. It could be defined as a state of complete physical, mental and social well-being. *When people are healthy, they are more efficient at work. This increases productivity and brings economic prosperity* (NCERT, 2006a, p.148, emphasis added).

In the aforementioned quote, we find the a collocation of words like efficiency, work, productivity and prosperity with health. This is in turn suggestive of a utilitarian view of the body – where it is viewed as something that needs to be economically productive – out of which surplus value needs to be extracted for efficient integration into the capitalist system.

The textbook also upholds an understanding of health on which modern medicine (allopathy) is based and dismisses other systems of medical knowledge such as Ayurveda, which are still practiced in India as historical and dated:

> Health for a long time *was* considered as a state of body and mind where there was a balance of certain humors. This is what early Greeks like Hippocrates and Indian Ayurveda system of medicine *asserted*. It was thought that person with black bile belonged to hot personality and would have fevers. The idea was

> arrived at by pure reflective thought. The discovery of blood circulation by William Harvey using experimental method and the demonstration of normal body temperature in person's with blackbile using thermometer disproved the good humor hypothesis of health in later years (NCERT, 2006a, p.145, emphases added).

It is interesting that Ayurveda is referred to in the past tense, as though it has ceased to exist! Modern western medicine (which has now efficiently joined hands with capitalism) is projected as a superior form of knowledge owing to its use of the experimental method while Ayurveda and Yunani, which form an important part of the alternative health care system in India are relegated to the domain of "pure reflective thought" (what this even means is not substantiated) and is portrayed as lacking.

The sociopolitical factors that affect health such as poverty, lack of access to health care facilities and nutrition are not mentioned when the textbook discusses causes of ill health. It merely reduces the causes to genetics, infections and life style factors. The following excerpt from the chapter on Human heath and disease is suggestive of this emphasis:

Of course, health is affected by -

> (i) genetic disorders – deficiencies with which a child is born and deficiencies / defects which the child inherits from parents from birth
>
> (ii) infections
>
> (iii) lifestyle including food and water we take, rest and exercise we give to our bodies, habits that we have or lack etc. (NCERT, 2006a, p.145)

The textbook goes on to advise individualized ways to maintain good health which involve consuming a balanced diet, regular exercise and practicing yoga. The necessity for proper disposal of waste, control of food and water borne diseases are mentioned, but there is no discussion of whose responsibility it is to attend to these aspects or why there is a severe health crisis in the country. It is only in the chapter on strategies for enhancement of food production (chapter 9) that there is a mention of malnutrition and poverty as the cause for it:

> A far greater number-three billion people- suffer from micronutrient, protein and

> vitamin deficiencies or 'hidden hunger' because they cannot afford to buy enough fruits, vegetables, legumes, fish and meat. (NCERT, 2006 a, p.175)

However, the textbook suggests technological solutions to the problem through biofortification of cereals and production of single cell protein, instead of discussing why the cost of vegetables, legumes, fish and meat is exorbitant and why people cannot afford them in the first place.

Thus, the textbook appears to be reinforcing the health policies of the current neoliberal order. Rao (2000) argues that the current neoliberal health policies in India ascribe disease occurrence:

> … to individual proclivities and failures. As we witness increasing privatization of health care, along with cuts in state spending on health, we see a reversal toward technologically driven vertical programmes. Thus while a holistic vision of public health has been eclipsed, the chicken of technological determinism and methodological individualism has come home to roost with a vengeance. (p. 4319)

Towghi (2013) also notes that, “India has rapidly become central to the emerging global ‘bio-economy’ and an attractive destination for individuals, pharmaceutical corporations, and medical institutions from around the world for purposes of research, drug trials, or treatment”(p.329).

The topic of reproductive health, where preventive dimensions of reproductive health also falls prey to a similar kind of treatment and we find that preventive dimensions of reproductive health are underplayed and dangerous procedures and technologies that facilitate reproductive health are being marketed (Raveendran & Chunawala, 2015). Rao (2000) and Qadeer (2010) point out that reproductive health cannot be understood in isolation from overall health which current policies ignore. Also, the reproductive health policies are primarily directed at fertility control while other aspects are underplayed (Narayanan, 2011). This tendency is also reflected in the textbook where there is a lengthy discussion of topics such as contraception and infertility (detailed discussion in chapter 3).

2.7.2 Human population

A major anxiety that reappears now and then in the textbook is population explosion and ways to control it. The population problem is introduced in the chapter Reproductive health where the “alarming” rate of population growth is discussed:

> ...Such an *alarming* growth rate could lead to an absolute scarcity of even the basic requirements, i.e.,food, shelter and clothing, in spite of significant progress made in those areas. Therefore, the government was forced to take up serious measures to check this population growth rate. The most important step to overcome this problem is to motivate smaller families by using various contraceptive methods (NCERT, 2006a, p.59).

The population explosion problem is also reiterated in other chapters:

> ...Human population size has grown *enormously* over the last hundred years. This means increase in demand for food, water, home, electricity, roads, automobiles and numerous other commodities. (NCERT, 2006a, p.270, Environmental Issues)

> ...we have been concerned about *unbridled* human population growth and problems created by it in our country and it is therefore *natural* for us to be curious if different animal populations in nature behave the same way or show some restraints on growth. Perhaps we can learn a lesson or two from nature on how to control population growth. (NCERT, 2006a, p.229, Organisms and Populations)

In the above excerpts, the unqualified use of the words alarming, enormous and unbridled when discussing population growth play up the magnitude of the population problem. Fertility control of developing countries has been on the agenda of the first world as well as global neoliberal institutions such as the World Bank which are haunted by the dystopian spectre of the teeming millions in these countries consuming all of the world's resources (Sen, 1994). Besides this, evidence suggests that the fertility rates in India have reduced in the period between 1992 and 2006 (Narayanan, 2011).

The textbook also uses the rationale of increasing population to make the malthusian

argument of the need to enhance food production. “With ever increasing population of the world, the enhancement of food production is a major necessity”. (NCERT, 2006a, p.165, Strategies in Enhancement in Food Production). Population explosion is not the only cause of the global food crisis. Latter is linked to several other factors such as the linking of agriculture to the world market and agribusiness and the further impoverishment of “agricultural producing regions through the replacement of bio-regionally evolved farming practices, knowledge and seeds with industrial methods and technologies built on a model of agricultural science that abstracts from local social and ecological conditions” (p.120, McMichael & Schneider, 2011).

2.7.3 Sex, gender and sexuality

There are only two sexes and two genders in the textbook. A glance at the topics discussed in the chapter Human Reproduction reveals this: the male reproductive system, the female reproductive system, gametogenesis, menstrual cycle, fertilization and implantation, pregnancy and embryonic development and parturition and lactation. All topics clearly delineate two sexes and are silent on variations. A simple keyword search employing the words women/woman reveals how the textbook uses sex and gender interchangeably, assuming that there is an unproblematic correspondence between the two (Appendix IV).

With regard to the values that the textbook upholds regarding sexuality, we witness a celebration of the heteronormative, malthusian sexuality (Repo, 2013) of the young, middle class urban couple:

> You might have seen advertisements in the media as well as posters/bills etc., showing a *happy* couple with two children with a slogan Hum Do Hamare Do (we two, our two). *Many couples, mostly the young, urban, working ones* have even adopted a 'one child norm' (NCERT, 2006a, p.59, emphases added)

Note the use of the adjective “happy” when referring to the young, urban couple who adopt the one child population control norm. What is being accomplished here, with subtlety, is a consensus (or what Fairclough (1989) refers to as relational modality) with the reader that to follow the norm is desirable, which in turn brings happiness.

Another excerpt that reinforces heterosexual monogamy is from the chapter Reproductive Health where the technique of In Vitro Fertilization is discussed:

> ...In this method known as the Test tube baby programme, ova from the *wife/donor* (female) and sperms from the *husband/donor* (male) are collected and induced to form zygote under simulated conditions in the laboratory. (NCERT, 2006a, p.64, emphases added)

By interchangeably using the words wife, husband and donor (thus establishing a relationship of synonymy between these words), the text remains silent about other possible users, reinforcing institutionalized heterosexual monogamy (which excludes same sex couples, individuals who have undergone sex change or may not be able to reproduce due to other impairments).

The textbook discourse also pathologizes bodies that deviate from the malthusian norm, which are incapable of fostering life or continuing the species. This is particularly evident in the discussion on sex chromosomal “disorders” in the chapter Inheritance and Variation (chapter 5). Here, what gets projected as “abnormal” about individuals with sex chromosomal disorders is feminization or the lack thereof in the Klinefelter male and the Turner female respectively. (Figure 2.1). Other physiological problems are not highlighted, such as the fact that Turner's women tend to have Diabetes or cardiac problems.

In a similar manner, in the discussion of anabolic steroids in the chapter Human Health and Disease, masculinization and feminization of the female and male body respectively are discussed as side effects:

> The side effects of the use of anabolic steroids in females include masculinisation (features like males), increased aggressiveness, mood swings, depression, irregular menstrual cycles, excessive hair growth on the face and body, enlargement of clitoris, deepening of voice. In males it includes acne, increased aggressiveness, mood swings, depression, reduction of the size of testicles, decreased sperm production, potential for kidney and liver dysfunction, breast enlargement, premature baldness, enlargement of prostrate gland. (NCERT, 2006a, p. 162)

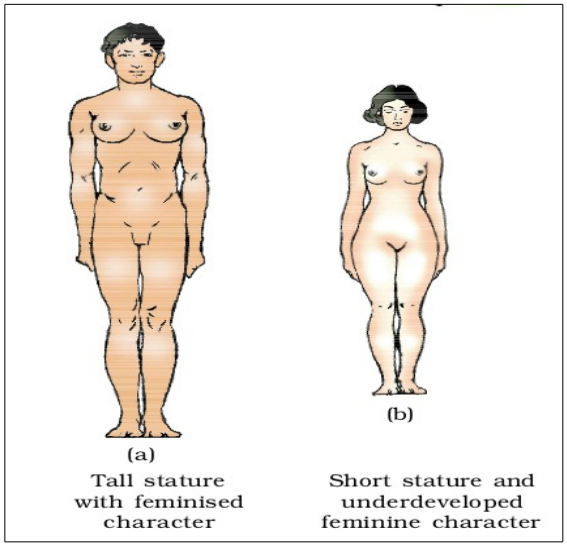

Figure 2.1 Pathologization of infertile bodies

(Source: NCERT class XII Biology Textbook, Page no. 91)

It is particularly interesting in the aforementioned quote, that for females, symptoms that amount to 'masculinization' seem to be the most overwhelming 'side effect', while very few physiological side effects are discussed.

The definition of reproductive health in the textbook also appears to suggest, in an indirect way, that bodies which do not reproduce or engage in “normal” sexual behavior (read non heterosexual relationships) are aberrant in some way. This is further discussed in chapter 3 of this thesis.

2.7.4 The non-human world

In this section I discuss how the textbook discourse discusses the non-human world in relation to human needs, the value it ascribes the non-human world and the causes it attributes to environmental disturbances. The textbook has a largely anthropocentric focus where human life is valued over other forms of life. A running theme in the textbook is the need to feed the increasing population of the world and harness the extended non-human world in service of this agenda:

> With ever increasing population of the world, the enhancement of food production is a major necessity. Biological principles, as applied to plant breeding and animal husbandry have a major role in our efforts to increase food production. Several new techniques such as embryo transfer and tissue culture are going to play a pivotal role in enhancing food production (NCERT, 2006a, Strategies for enhancement of food production, p.165)

Likewise, in chapters such as Strategies for Enhancement in Food Production, topics such as animal husbandry discuss *management* of farm animals (dairy, poultry and fisheries), with little heed paid to the discussion of humane treatment of these living beings centering *their wellbeing*. The following excerpt, for instance exemplifies this stance:

> For the yield potential to be realised the cattle have to be well looked after-they have to be housed well, should have adequate water and be maintained disease free. (NCERT, 2006a, p. 166)

A similar anthropocentric approach is echoed in the Biodiversity and Conservation:

> Biodiversity and conservation are now vital environmental issues of international concern as more and more people around the world begin to realise the critical importance of biodiversity for *our* survival and well being on the planet. (NCERT, 2006a, p. 259, emphasis added)

Above, conservation is posited as an important need as “our” survival on the planet is perceived to be under threat. The language used in the discussion of ecosystems and the “services” they provide to us is also suggestive of a view of the ecosystem as something that can be commodified and valued:

> Healthy ecosystems are the base for a wide range of economic, environmental and aesthetic *goods and services*... though *value* of such *services* of biodiversity is difficult to determine, it seems reasonable to think that biodiversity should carry a *hefty price tag*. Robert Constanza and his colleagues have recently tried to put *price tags* on nature's *life support services*....which are largely taken for granted because they are *free*. (Ecosystem, p.255, emphases added)

The specific collocations of italicized words and metaphors (Fairclough, 1989) in the above excerpt are all from the field of economics and are deliberately used to convey an anthropocentric sense of nature, where it is viewed as a resource to be consumed in order to satisfy human needs.

On similar lines, in the chapter on biodiversity and conservation, there is some discussion on why we need to conserve biodiversity. Three broad arguments are outlined, the first one being the “narrowly utilitarian” argument:

> countless *direct economic benefits* from nature - food (cereals, pulses, fruits), firewood, fibre, construction material, industrial products (tannins, lubricants, dyes, resins, perfumes) and *products of medicinal importance*. More than 25 percent of the drugs currently sold in the market worldwide are derived from plants contribute to traditional medicines used by native peoples around the world. Nobody knows how many more *medicinally useful plants* there are in tropical rain forests *waiting to be explored*. With i*ncreasing resources put into 'bioprospecting'* (exploring molecular genetic and species-level diversity for products of economic importance), nations endowed with rich biodiversity can expect to *reap enormous benefits*. (NCERT, 2006a, p.265, emphasis added)

In the above excerpt again, one finds the deployment of words that suggest a utilitarian view of the ecosystem. The second is the “broadly utilitarian” argument:

> ... The broadly utilitarian argument says that biodiversity plays a major role in many ecosystem *services* (emphasis added) that nature provides. The fast dwindling amazon forest is estimated to produce, through photosynthesis, 20 per cent of the total oxygen in earth's atmosphere. Can we put an economic value on the *service* by nature? ...pollination (without which plants cannot give us fruits or seeds) is another *service* ecosystems provide through pollinators...there are other *intangible benefits*-that we derive from nature- the aesthetic pleasures of walking through thick woods, watching spring flowers in full bloom or waking up to a bulbul's song in the morning. *Can we put a price tag on such things?* (NCERT, 2006a, p.266, emphases added)

Above, we find the word *services* being repeatedly employed. Nevertheless, the last line conveys a sense of reflexivity regarding the appropriateness of ascribing an economic value to nature.

The third is the the “ethical argument”:

> ... The ethical argument for conserving biodiversity relates to what we owe to millions of plant, animal and microbe species with whom we share this planet. Philosophically or spiritually, we need to realise that every species has an intrinsic value, even if it may not be of current or any economic value to us. We have a moral duty to care for their well being and pass on our biological legacy in good order to future generations. (NCERT, 2006a, p.266, emphases added)

What gets discussed as the “ethical argument” appears to be the biocentric perspective. It is not clear why this argument alone gets assigned an “ethical” value, while other arguments are not.

In sum, we find that the three different arguments for preserving biodiversity are not weighed against each other, giving the impression that both teachers and students can choose to accept whichever argument appeals to them. Furthermore, the relative ordering and space afforded to each of the arguments, as well as the fact that the utilitarian argument, as embodied in the concept of ecosystem *services*, has already been introduced in the chapter on ecosystems gives the impression that the utilitarian argument has been ascribed a higher status than the ethical argument by the textbook. The textbook has several such excerpts where a strong anthropocentric stance is pronounced (Appendix III).

That the textbook subscribes to the broadly utilitarian argument is also reinforced by the introductory lines in the chapter on environmental issues:

> ... Human population size has grown enormously over the last hundred years. This means increase in demand for food, water, home, electricity, roads, automobiles and numerous other commodities. These demands are exerting tremendous pressure on our natural resources, and are also contributing to pollution of air, water and soil. *The need of the hour is to check the degradation and depletion of*

> *our precious natural resources and pollution without halting the process of development*. (NCERT, 2006a, p.270, emphasis added)

The idea of development being advanced here is one of sustainable development (ensuring development without resource depletion) which is a running theme in the NCERT secondary science textbooks as well. This perspective has been critiqued as it fits the ecological modernization framework which advocates unfettered development without questioning human needs or consumption patterns (Srivastava & Haydock, 2014).

A utilitarian and anthropocentric discourse is also employed in the discussion of organic farming. A reference to organic farming first appears in the chapter Microbes in Human welfare in a section titled “Microbes as biocontrol agents”. It is described as offering “a method of controlling pests that relies on natural predation rather than introduced chemicals” (NCERT, 2006 a, p.187). Further, it is mentioned that:

> the organic farmer holds the view that the eradication of creatures that are often described as pests is not only possible, but undesirable, for without them the beneficial predatory and parasitic insects which depend upon them as food or hosts would not be able to survive (NCERT, 2006a, p.188).

Above, the need to retain “pests” is argued in terms of their utility in serving as food for beneficial insects. Organic farming is also discussed in the chapter Environmental Issues. Here, the discourse employed is even more utilitarian:

> Integrated organic farming is cyclical, zero-waste procedure, where waste products from one process are cycled in as nutrients for other processes. This allows *the maximum utilisation of resource* and *increases the efficiency of production* (NCERT, 2006a, p.280, emphases added).

The vocabulary used effectively transforms farming, a socioculturally embedded activity into an efficient, zero-waste procedure .

At one section, in the chapter Biodiversity and Conservation, the textbook acknowledges the tension between economic development and conservation:

> Faced with the conflict between development and conservation, many nations find

> it unrealistic and economically not feasible to conserve all their biological *wealth*. Invariably, the number of species waiting to be saved from extinction far exceeds the conservation resources available (NCERT, 2006a, p.266, emphasis added)

Although the conflict is acknowledged, anthropocentrism trumps biocentrism when the textbook eventually states that nations find it unrealistic and economically non-viable to conserve all "biological wealth".

The textbook goes on to a discussion of various conservation efforts, the identification of biodiversity hotspots and the setting up of biosphere reserves and national parks. However, in the same breath it also discusses "religious and cultural traditions" that emphasize protection of nature. The chapter Environmental Issues, for instance, romanticizes the contribution of certain tribal communities in conservation efforts. The *Chipko* movement as well as the story of Amrita Devi of the Bishnoi community are mentioned and the need for joint forest management involving local communities are stressed (Appendix III). However, the discussion of these conservation efforts, albeit laudable, do not fit well with the overall philosophy of conservation and biodiversity that the textbook holds, which is broadly utilitarian. The worldviews and philosophical basis of these traditions emphasized biocentrism and living in harmony with nature.

2.7.5 Technology and risk in the textbook

In an article that maps the debate on biotechnology in India, Visvanathan and Parmar (2002) observe that there are a range of voices that capture the politics of anxiety and hope around biotechnology. At one end, we have the uncritical advocates of biotechnology who believe that discussion of bioethics in developing countries is irrelevant, as our major concern ought to be addressing food security. At the other end, we have polemical postcolonial perspectives such as those echoed by Vandana Shiva who view biotechnology as being anti-woman, anti-farmer and anti-nature. They wind up the article pointing out that the Indian democracy is yet to understand the idea of risk, suggesting that ethical questions need to revolve around the question of risk. What I find is that the discussion around risk is inconsistent in the textbook. While there is a mention or discussion of risk associated with certain technologies, for others

it is discussed to a lesser degree or not acknowledged. This suggests that a detailed discussion of risks is not a priority of the textbook.

The chapter on environmental issues is devoted to a discussion of disturbances in the environment caused by human activity. The topics covered include air pollution and control, water pollution and control, solid waste, effects of agrochemicals, nuclear waste, the green house effect, degradation by improper use and maintenance and finally, deforestation. All the problems and issues associated with various human interventions on nature are lumped together and discussed in this chapter along with probable solutions from a sustainable development perspective. For instance, there is a discussion on deleterious effects of the agrochemicals on the environment when it discusses green revolution technologies:

> In the wake of the green revolution, use of inorganic fertilizers and pesticides has increased many fold for enhancing crop production. Pesticides, herbicides, fungicides etc. are being increasingly used. These incidentally are also toxic to non target organisms that are important components of the soil ecosystem...we know what the addition of increasing amounts of chemical fertilizers can do to aquatic ecosystems vis-à-vis eutrophication. The current problems in agriculture are therefore grave. (NCERT, 2006a, p.279)

> … water logging and soil salinity are some of the problems that have come in the wake of green revolution. (NCERT, 2006a, p.283)

The textbook also adopts a skeptical stance towards nuclear waste. In the section dealing with this topic, it directly launches into a discussion of concerns regarding accidental leakage and effects of radiation. There is also mention of public resistance towards these technologies:

> It has been recommended that storage of nuclear waste, after sufficient pre-treatment should be done in suitably shielded containers buried within rocks, about 500 m deep below the earth's surface. However, this method of disposal is meeting stiff opposition from the public. Why do you think this method of disposal is not agreeable to many people? (NCERT, 2006a, p.280).

The government of India has a pro-nuclear stand and has been indifferent to the public angst surrounding nuclear reactors post-fukoshima (Varughese, 2012). Though the above excerpt does not suggest explicit support to the public resistance towards nuclear energy, the framing of the text (in the form of an open-ended question where public discontent is explicitly acknowledged) is such that there is possibility of bringing these discussions into the classroom. The issue of risk is also raised in the discussion on remediation of e-waste:

> ... E-wastes are buried in landfills or incinerated. Over half the e-wastes generated in the developed world are exported to developing countries, mainly to China, India and Pakistan, where metals like copper, iron, silicon , nickel and gold are recovered during recycling process. Unlike developed countries, which have specifically built facilities for recycling of e-wastes, recycling in developing countries often involves manual participation thus exposing workers to toxic substances present in e-wastes. Recycling is the only solution for treatment of e-waste, provided it is carried out in an environmentally friendly manner (NCERT, 2006a, p.279).

Here, one finds that in addition to a reference to risks, it is also explicitly mentioned that the burden of risk falls on the workers of the recycling industry in the third world. However, unlike the discussion of nuclear waste, the framing of the text does not leave room for discussion of the politics of why most of the recycling happens in the third world or whether it is fair that workers get exposed to toxic substances while recycling when alternatives exist. The teacher would explicitly have to bring these discussions up in the classroom.

On the discussion of risks around the new biotechnologies involving Genetically Modified organisms (GMOs), the textbook is more reticent. There is a mention of the ecological impacts of introducing GMOs in the chapter on biotechnology and its applications: “Genetic modification of organisms can have unpredictable results when such organisms are introduced into the ecosystem.” (NCERT, 2006a, p.213). However, the textbook goes on to say that a “Genetic Engineering Approval Committee which will make decisions regarding the validity of GM research and the safety of introducing GM organisms for public services” (NCERT, 2006a, p.213), totally disregarding the role of the public in decision making on such issues.

In contrast to the above mentioned technologies, the discussion of risk around reproductive technologies is very limited (discussed in chapter 3).

According to Qadeer (2010), the middle classes' excessive faith in technology to deliver “economic, social and environmental justice” has lead to the domination of technologies in all spheres of life. This view is tied up with the notions of mechanistic control over nature as well as technological determinism where technology is seen as autonomous and independent of social control. This has also lead to technology being instrumental in “market oriented developmental processes in societies”. Referring to the work of philosopher Andrew Feenberg, Qadeer points out that this autonomous view of technology that views it as interacting at its periphery with society has lead to a split between technical rationality and its experiential meaning where users' experience of technology are sidelined. Though technology has the potential to transform our lives in positive ways, it has been been “so trapped in the wheels of commercialization and free markets, that its progressive potentials have been obfuscated”. When technology becomes a means of earning profit, its control shifts from the hands of inventors to investors which leads to limited impact on society which includes the exclusion of a large portion of the population. The design of the technology also becomes less sensitive to user's needs and engenders risks to users. When technologies become subordinated to market forces, one of the major ramifications is the downplay of risk associated with these technologies. It is therefore important that the textbook actively resist deterministic notions of technology. In this reading of the class XII biology textbook, one finds that in certain contexts technology is discussed deterministically as in the sections on reproductive technologies; but when it comes to other topics such as green revolution, nuclear energy, e-waste and to some extent biotechnology, issues such as risk and intellectual ownership get discussed.

2.8. Conclusion

The analysis laid out here does not limit itself to what the textbook explicitly brackets out as ethical, social or political but also examines the implicit values and ideologies that get transmitted in the discussion of topics like health, sexuality, reproductive health, the non-

human world and population where we find the definitions and vocabulary used supporting the ideologies of the neoliberal capitalism and heternormative patriarchy.

While on the surface the textbook discourse promotes values that support (often regressive) agendas of the state-industry complex, there are undercurrents of resistance against these agendas as evident in the discussion of conflicts around topics such as biotechnology and environmental issues. At one extreme, for certain topics such as nuclear waste, public resistance and issues of risk are acknowledged while at the other extreme, in the discussion of topics such as reproductive health, the state's regressive agendas of top down fertility control is promoted while there is no acknowledgement, in any sense, of the epistemological as well as political critiques raised by the womens' health movement. Somewhere in the middle of this ideological spectrum, we find topics such as biotechnology where public resistance or environmentalists' concerns and risks are sidelined, though issues such as biopiracy are discussed.

As pointed out earlier, Visvanathan & Parmar (2002) opine that ethical discussions on technoscience should center around questions of risk. What I find is that though there is some acknowledgement of risk around certain technologies, the textbook does not pay any attention to the skills needed to evaluate the nature and extent of risks. Knowledge is treated as a commodity by the textbook, evident in the discourse on patenting and ownership. Indigenous knowledge is viewed as something that can be tapped into by modern science, through patenting regimes. The nature of indigenous knowledge is not dwelt upon and portrayed as inferior to modern western science.

Overall, I observe that values and ideologies expressed in the textbook are conflicting and do not reflect any particular monolithic agenda. This indicates that careful attention is not being paid to the kind of values that are getting conveyed through the textbook. This treatment is consistent with the position paper's advocacy for science education at the higher secondary level, which gives primacy to teaching facts and relegates STS concerns to the periphery. I, therefore, argue that it is important that textbooks begin to reflect the value conflicts around the technosciences as well as topics that fall within the science-society interface. Besides this, committees that write textbooks need to acknowledge value conflicts inherent in these topics as well as think through which values, why and how they need to be incorporated, with the

understanding that values cannot be kept out of discussing these topics. Otherwise, there is a danger of regressive and oppressive agendas of the state and neoliberal global capitalism percolating into the textbook. For this purpose, science textbook writers need to engage with the wide range of STSE scholarship existing in the country and worldwide on the various topics discussed in this chapter.

CHAPTER 3

REPRODUCING VALUES: A FEMINIST CRITIQUE OF REPRODUCTIVE HEALTH IN THE HIGHER SECONDARY BIOLOGY TEXTBOOK

3.1. Introduction

This chapter employs a feminist critique to explore the ways in which values get communicated in the class XII biology textbook chapter on reproductive health. This chapter is being given specific focus because it serves as a context to make sense of the subsequent chapters of this thesis which focus on students' negotiation of socioscientific issues pertaining to reproductive technologies. Feminist critiques of the science curriculum have been done in other cultural contexts (Brotman & Moore, 2008; Hughes, 2000; Mayberry, 1998 and Richmond, Howes, Hazelwood, 1998). Mayberry (1998) classifies the range of these critiques into two broad categories: reproductive and resistant. While the reproductive approaches focus more on the pedagogy of science and attempt to incorporate learning styles and examples that are closer to the lived experiences of girls and ethnic minorities into the curriculum, they essentially reproduce the knowledge structure without questioning it. Resistant approaches, on the other hand, traverse a step further to question the fact-value dichotomy[9] that is rigidly maintained in science curriculum and seeks to reposition science in a socio-political context. This chapter will, from a resistant perspective, discuss the manner in which social, political and ethical concerns get discussed in the chapter on reproductive health in the class XII biology textbook (NCERT, 2006). The analysis presented here has been reported in Raveendran & Chunawala (2015).

9. Fact-value dichotomy: Enlightenment doctrine which upheld the distinction between fact (what can be reasoned about and lies in the realm of science) and values (which are a matter of personal judgement and personal taste). This dichotomy has been questioned by post-positivist philosophers of science.

3.2 Feminist critiques of reproductive health policies and technologies in India

To make sense of how values and science intersect in the discussion of reproductive health we take into account the wealth of feminist scholarship in India that has critiqued reproductive health policies of the state (Manorama & Shah, 1996; Narayanan, 2011; Qadeer, 2009, 2010) as well as the technologies that have been promoted by these policies and interweave this literature in our analysis of the textbook.

Rao (2000), in a historical account of the evolution reproductive health policies in India discusses how vertical and technology dominated initiatives focusing on controlling family sizes have never succeeded in the absence of health care policies that look into overall development of the population (in matters such as health, education, food, water, employment etc). Further, Narayanan (2011) points out that India's health policy has been supported by international agencies such as the World Health Organization, World bank and the United Nations Population Fund and is therefore subject to their demands and pressures. For example, organizations like the world bank have demanded the retraction of state expenditure on health to favour the private sector. This has adversely impacted a vast majority of the population in the country who are unable to access basic health care (Rao, 2000). It is in this context that we need to place the latest population control programmes (such as the RCH initiatives[10]) with their language of reproductive rights and choice, which have essentially borrowed the western feminist discourse that emphasizes women's autonomy over their own bodies in the context of issues such as abortion rights. This discourse, according to Rao (2000), has been co-opted to serve the neoliberal agenda of creating 'a “rational”, utility maximizing consumer in the contraceptive market place produced by the reproductive technology industry of the west' (p. 4320). Qadeer (2010) argues that the same rhetoric of reproductive rights and choice have been used to introduce Assisted Reproductive Technologies (ARTs) (also offered by the private sector). These technologies, by serving to reinforce patriarchal conceptions of genetic parentage and claiming to liberate the poor who can now sell their reproductive potential, find a market in the developing world among the middle classes and also attract reproductive tourism.

10 RCH stands for Reproductive and Child Health Programme.

It is also important to mention the epistemological and political questions raised on reproductive technologies by the women's health movement which has mounted strong resistance against the indiscriminate use of reproductive technologies that are unsafe and exploitative of women's bodies. This scholarship questions the science behind the technologies that are designed to interfere with the working of the menstrual cycle than be in harmony with it. Contraceptive drugs, for instance, are designed with an instrumental and reductionist view to preventing the event of fertilization of the gametes, ignoring other systemic dimensions of the menstrual cycle (Manorama & Shah, 1996).

3.3 NCERT textbook chapter on reproductive health

The chapter on human reproductive health in the NCERT biology textbook is the fourth chapter in a unit on reproduction that discusses the reproductive mechanisms of different kinds of living organisms. The chapter is divided into five sections: Reproductive Health: Problems and strategies, Population explosion and birth control, Medical Termination of Pregnancy (MTP), Sexually Transmitted Diseases, and Infertility. Interestingly, two of the sections - population explosion and birth control have been given more coverage than other topics.

Why is reproductive health a concern for the biology curriculum? It appears that the chapter was included in the textbook with an understanding that students will be future professionals who will provide these services and technologies to facilitate reproductive health. The syllabus document, for instance, points out that the syllabus at this level is meant to provide ' substantial orientation to the students to professional/career opportunities available in medicine, agriculture, research, teaching and industry' (p.1). Personal correspondence with one of the members of the textbook writing[11] team also reveals that the chapter has been included with view to educating students on 'applied aspects' of biology.

What kind of values does the textbook aim to impart in these future professionals? The manner in which the chapter is written seems to suggest inculcating a cold rationality which is

11 The textbook writing process was a collective process and took place in the year 2005-2006. Each chapter was written by a team comprising scientists, college and school teachers. Therefore, one person's view may not capture the complete picture of the negotiations and decisions that happened during the textbook writing process. However, it may still afford a reasonable insight into the primary motivations behind why this topic was included.

blind to the subjective experience of the technology. This is suggestive in the singular focus of the chapter on descriptions of the principles on which reproductive technologies work with the jarring omission of discussion of side-effects of these technologies. This in turn enforces a certain kind of technical rationality over the experiential meaning of the technology. Besides this, there is hardly any attempt to discuss reproductive health from a more holistic, preventive dimension and connect it with larger questions pertaining to general health.

This would be completely at odds with what proponents of politicized science education like Hodson (2003) would argue – that we can regulate technology and should promote technological choice, wherein citizens can decide for themselves which technology they choose to adopt. Adoption of appropriate technology would involve rejection of “any technology that violates our moral-ethical principles, exploits or disadvantages minority groups, or has adverse environmental impact” (Hodson, 2003). The goal, as posited by him, should be to promote 'humanized technology: a technology more in harmony with people and with nature' (p. 662).

We find that the chapter appears to be devoted to the uncritical marketing of technologies used to facilitate reproductive control and fertility assistance. Descriptions of these technologies take up large sections of the chapter. Other important dimensions of reproductive health like maternal and child well being, control of STDs, pregnancy and medical termination of pregnancy are discussed but not given priority. The latter aspects, which have more to do with individual’s well being and welfare are not fore-grounded. Our critique of the chapter on reproductive health is divided into three sections. The first section discusses how reproductive health is defined with a focus on 'whom' and 'what' this definition includes and excludes. The second and third sections are devoted to critiquing how population control and infertility are presented, drawing on feminist critiques of these technologies. These sections were of interest because of the critiques mounted by the women's health movement against these technologies in the country which have been discussed in one of the previous section.

3.4 How reproductive health is defined by the textbook

Reproductive health is defined as follows in the chapter:

> ... reproductive health means a total *well being* (emphasis added) in all aspects of

> reproduction, i.e., physical, emotional, behavioural and social. Therefore, a society with people having physically and functionally *normal* (emphasis added) reproductive organs and *normal* (emphasis added) emotional and behavioral interactions among them in all sex-related aspects might be called reproductively healthy (NCERT, 2006a, p.57, emphases added).

The definition establishes a synonymy between the words normal and well being, pathologizing people with different gender identities or sexual preferences whose experiences of reproductive health may be very different. Such definitions based on the idea of normality also make it easier to propose technological fixes to correct abnormalities. The lack of acknowledgement of sexual diversity in the biology curriculum has also been pointed out by Snyder and Broadway (2004) in their study of the American curriculum:

> Sexuality is a science-content area, yet sexuality as a topic in learning science is silenced. Sexual diversity is made invisible in the curriculum and science textbooks by the heteronormative lens of Darwinian reproductive drive. If science is for all, and relevancy is essential to learning, then a new lens must be fitted over the textbook to see the invisible for which heterosexuality is not the normative lifestyle (p. 618).

As posited by the textbook, reproductive health for adolescents constitute: "...proper information about reproductive organs, adolescence and related changes, safe and hygienic sexual practices, sexually transmitted diseases, AIDS, etc." (NCERT, 2006a, p. 58). While for adults, the textbook advocates:

> Educating people especially fertile couples and those in marriageable age group about available birth control options, care of pregnant mothers, post-natal care of mother and child, importance of breast feeding, equal opportunities for the male and female child would address the importance of bringing up socially conscious healthy families of *desired* size. Awareness of problems due to uncontrolled population growth, social evils like sex-abuse and sex related crimes need to be created to enable people to think and take up necessary steps to prevent them and thereby build up a socially responsible and healthy society (NCERT, 2006a, p.58).

Here, there is an attempt to discuss several dimensions of reproductive health, but even in the ordering of aspects related to reproductive health, birth control is given first priority.

3.5 Population explosion and birth control

After providing the definition of reproductive health, the textbook launches into a discussion of birth control technologies. Population explosion is cited as the reason why an individual ought to employ them. The section begins with an explanation of the causes for population explosion: “In the last century an all-round development in various fields significantly improved the quality of life of the people. However, increased health facilities along with better living conditions had an explosive impact on the growth of population” (NCERT, 2006a, p. 58).

There is however enough literature (Narayanan, 2011; Rao, 2000; Sen,1994) to suggest that with better access to health facilities and better living conditions, people automatically *choose* to have smaller families. Sen (1994) summarizes two broad approaches to population control: the override and collaborative approaches. The former uses coercive economic and legal pressures for population control while the latter focuses on overall social and economic development as a means to achieve population stabilization. The latter views people as capable of taking reasoned decisions on birth control on their own if they are provided with a sense of personal security by the state (through provision of welfare measures like improved access to health care, education and old-age security). Sen further suggests that a central aspect to bringing down birth rates is a focus on measures that would bring about women's empowerment. With access to educational opportunities and political activity, women would make their own decisions regarding contraception, and decide to avoid the drudgery of repeated pregnancies and child care. The population control policy of the state is, however, coercive and top down and we find the textbook justifying it by pointing out how the population growth rate is 'alarming':

> Such an alarming growth rate could lead to an absolute scarcity of even the basic requirements, i.e., food, shelter and clothing, in spite of significant progress made in those areas. Therefore, the government was *forced* to take up *serious* measures to check this population growth rate. The most important step to overcome this

> problem is to motivate smaller families by using various contraceptive methods (NCERT, 2006a, p. 59, emphases added).

But the truth remains that that the measures used by the government were coercive[12], while the text uses the euphemism “serious”, downplaying the inhuman nature of these measures. Narayanan (2011) points out that the population growth rate is not as alarming as it is being made out to be. The data from the National Family Health Surveys conducted between 1992 and 2006 suggests that the fertility rate came down drastically in this period, yet the textbook advocates 'serious measures' to check population growth:

> Statutory raising of marriageable age of the female to 18 years and that of males to 21 years, and incentives given to couples with small families are two of the other measures taken to tackle this problem (NCERT, 2006a, p. 59).

There is no critical discussion of whether incentive based top-down measures are appropriate or not. Narayanan (2011) discusses how reproductive health policy in India has always had to “straddle a treacherous fault line between target driven population control goals on the one hand, and issues of individual reproductive rights and general well being on the other” (p. 39). Tracing the history of reproductive health policies in the country, she points out that though the discourse of these policies has become more progressive sounding over the years, on the ground, coercive measures continue to be taken which include forced sterilization as well as the offering of incentives and disincentives to compel people to take up birth control measures. The population control measures in the country have also been subject to international pressure, particularly by the first world nations who are haunted by the spectre of teeming millions of the third world multiplying and consuming the limited resources of the world, polluting and degrading it and emigrating into their nations (Sen, 1994; Connelly, 2006). Connelly's (2006) historical account of the early debates on population control in India also show how it has been driven by eugenic and neo-Malthusian agendas - agendas that advocate birth control measures reflecting eugenic concerns about fertility of certain groups. These tendencies are manifested in the textbook's celebration of the young, urban couple who

12 Inhuman measures continue to be imposed to this day. A recent article brings to light sterilization deaths in a state-run camp where women were “herded like cattle”, without their consent. See for instance the following newsreport: https://www.theguardian.com/world/2014/nov/12/india-sterilisation-deaths-women-forced-camps-relatives

have successfully adopted the one-child norm (discussed in chapter 2 of this thesis), where, through the suggestive foregrounding of the young, urban couple, we find the textbook reinforcing prejudices towards the poor.

The section then moves on to a discussion of the various methods of contraception which include Natural/traditional, Barrier, IUDs, Oral contraceptives, Injectables, Implants and Surgical methods. Abstinence, coitus interruptus and lactational amenorrhea are discussed under a paragraph on natural methods. But the paragraph ends with a warning that chances of failure are high if these methods are resorted to. The next paragraph launches into a discussion of barrier methods. Though some of these methods are discussed in detail, the efficacy of these methods is not discussed. The textbook then turns to a discussion of more controversial and invasive technologies like Intra-Uterine Devices (IUD), oral contraceptives and emergency contraceptives. The first technology that is discussed is IUD. These devices are introduced as 'effective' and 'popular'. After a description of the method, the paragraph ends by stating that this is one of the most 'widely accepted methods of contraception.' There is no mention of side effects or any attempt to direct students' inquiry towards these aspects or that these contraceptives were forced upon women who came for any reproductive health needs (like deliveries or MTPs) to the public hospitals. The same is true with regard to the discussion on oral contraceptives: “Pills are very effective with lesser side effects and are well accepted by the females” (NCERT, 2006a, p. 60). Injections and sub-dermal implants are described as being similar to oral contraceptives and as being more effective.

Manorama & Shah (1996) discuss the chequered history of contraceptive technologies, the reductionism in the science underpinning these technologies and the ways in which they have been exploitative of women's bodies. Economic liberalization helped pharmaceutical companies carry out large scale testing of some very dangerous and invasive contraceptives in India. Women who were used for these drug-trials were uninformed and suffered several side effects. The women's health movement in India has been active in its campaigns against the unethical clinical trials of injectible contraceptives like Net En and Depo Provera and sub-dermal implants like Norplant (Forum for Women's Health, 1998) which had dangerous side effects.

A comparison of how the textbook discusses natural and barrier methods, vis-à-vis the more chemical and invasive methods also reveals that the latter are exalted and adjectives like 'effective', 'popular', 'widely accepted' and 'ideal' are used to refer to them.

Manorama & Shah (1996), however, point out that a woman is fertile only during five days of her menstrual cycle and need to use contraceptives only during that period. Some of the barrier methods are stated to have about 98% efficacy, do not intervene with the natural body cycle and have minimum side effects. The text not only chooses to overlook this information, but in fact appears devoted to the idea of selling the more invasive technologies, almost in accordance with the state's population control policy which has been providing the pharmaceutical industry free reign. We also witness the larger structure of the text completely precluding a discussion of safety of each of these methods, or users experiences of these technologies. only in the end do we see the safety concerns mentioned, but in an incidental manner. As Fairclough (1989) points out, these modes of structuring could have an effect on the schema of a person who is evaluating these technologies. The closing paragraph, in a superficial manner, discusses some of the side effects and refers to these as 'not significant':

> No doubt, the widespread use of these methods has a significant role in checking uncontrolled growth of population. However, their *possible ill-effects* like nausea, abdominal pain, breakthrough bleeding, irregular menstrual bleeding *or even* breast cancer, though not significant should not be totally ignored. (NCERT, 2006a, p. 62, emphasis added)

The second sentence in the above excerpt involves is rather complicated, with many disclaimers. It is not clear on what basis the side effects due to contraceptive use are written off as 'not significant', given the discussion above on the history of contraceptive technology in India and the resistance of the women's health movement towards the introduction of these contraceptives.

Towards the end of the discussion, the textbook recognizes that contraceptives are not needed for maintenance of reproductive health:

> One must also remember that contraceptives are not regular requirements for the maintenance of reproductive health. In fact, they are practices against a natural

> reproductive event, i.e., conception/pregnancy. One is *forced* to use these methods either to prevent pregnancy or to delay or space pregnancy due to personal reasons. No doubt, the widespread use of these methods have a significant role in checking uncontrolled population growth (NCERT, 2006a, p.62, emphasis added).

This makes us wonder why it discusses contraception at length and omits other aspects that directly relate to reproductive health or adolescent reproductive health in particular. Also, through the use of passive voice, “one is forced”, the text obfuscates agency (Fairclough, 1989); in this case, the role of the state in coercively imposing these methods of population control. There is also no effort to develop critical thinking in students, or encourage them to conduct inquiry on the efficacy of each of these methods. This may include directing them to independently look up information on the Internet, collect evidence by interviewing users of these technologies, reflect on their research designs and the credibility of secondary sources of evidence. Inculcating intellectual independence is particularly important given the complicit role of medical practitioners as agents of the state and pharmaceutical company (Van Kammen, 2000). The textbook, instead, emphasizes the need to rely on the expert authority of medical practitioners to make decisions regarding contraception: 'the selection of a suitable contraceptive method and its use should always be undertaken in consultation with qualified medical professionals' (NCERT, 2006a, p. 62).

3.6 Infertility

The section on infertility begins with the sentence 'Discussion on reproductive health is incomplete without a mention of infertility' (NCERT, 2006a, p. 63). Why does infertility necessarily have to be part of a discussion on reproductive health? This is not discussed. On the one hand, the textbook talks about bringing down the population and on the other hand it discusses fertility assistance making us wonder whose fertility is being discussed in these contexts. This is suggestive of the fact that certain bodies are regarded more as requiring their fertility to be controlled than others. While discussing infertility the textbook states:

> A *large number* of couples all over the world, including India are infertile, i.e., they are unable to produce children in spite of unprotected sexual cohabitation. The reasons for this could be many-physical, congenital, diseases, drugs,

> immunological or even psychological (NCERT, 2006a, p. 63, emphasis added).

In the above excerpt, we find the deployment of vague, yet definitive phrases like " a large number" in the text that effectively cajoles the reader into believing that infertility is a major problem. As posited by Fairclough (1989), a classification scheme constitutes a particular way of ordering or creating a reality by the deployment of particular kind of vocabulary. In the above excerpt, the listing of words suggest that causes of infertility can be placed within the individual – that relate to genetics and lifestyle, the social causes of infertility are specifically not mentioned. Qadeer (2009) points out that fertility is not as much a reproductive health problem as it is a problem of public health.

> Of the estimated 8-10% infertility in Indian women, 98% have secondary sterility, they have been pregnant at least once before but are unable to conceive again. Their problems are due to untreated disease, poor health care practices or malnutrition. Most of these can be avoided through effective antenatal and postnatal care and through good primary health care with basic facilities to diagnose and treat infertility (p. 28).

The textbook is completely silent on this matter. However, there is an attempt to bust the patriarchal myth of the woman being the sole cause of infertility: "In India often the female is blamed for the couple being childless, but more often than not, the problem lies with the male partner" (NCERT, 2006a, p. 64).

Following this, there is a discussion of various Assisted Reproductive Technologies (ARTs) that can be used to facilitate conception. According to the textbook:

> Specialised health care units (infertility clinics, etc.) could help in diagnosis and corrective treatment of some of these (fertility related) disorders and enable these couples to have children. However where such corrections are not possible, the couples could be assisted to have children through certain special techniques commonly known as Assisted Reproductive Technology (ART) (NCERT, 2006a, p. 64).

Here, we again find that the emphasis is on corrections through the use of technology and not prevention of malnutrition, improvement of hygiene or other means. That these are sophisticated technologies appears to serve as a rationale to include them in the textbook. Similar to the discussion on contraceptives, this section also reproduces a similar global text structure, with very important factors like side effects being omitted. Qadeer (2010) writes that the state, instead of providing for basic ways to redress the major causes of infertility like poor obstetric services, malnutrition and reproductive tract infections acts as a steward to ART industries that provide corrective services, which in turn bring revenue. Since the industry is profitable, the side effects of the technology are hidden. These technologies have low success rates and pose risks to the users which include the surrogate or gestational mother, the baby and the egg donor (Qadeer, 2009).

The last paragraph on infertility hastily refers to issues like access, the social and ethical issues that deter the use of these technologies and adoption as an alternative. On the issue of access, the textbook makes a reasonable point that these techniques require a lot of expertise to handle as well as expensive instrumentation, and that they tend to be expensive and affordable only to a few people.

On the socio-ethical dimensions of these technologies, the textbook makes an ambiguous statement: “Emotional, religious and social factors are also deterrents in the adoption of these methods” (NCERT, 2006a, p. 64), giving an impression that it is lamenting the lack of adoption of these methods due to these reasons. However, given the increasing popularity of these technologies in the present day context, this seems to be an incorrect statement.

The last line in the section on infertility makes a reference to adoption:

> ... Since the ultimate aim of these procedures is to have children, in India we have so many orphaned and destitute children who would probably not survive till maturity unless taken care of. Our laws permit legal adoption and it is as yet one of the best methods for couples looking for parenthood. (NCERT, 2006a, p. 64)

By recognizing adoption as one of the 'best methods', the text is effectively establishing synonymity between adoption and other “methods” of addressing infertility that seek to reinforce the idea of genetically linked families. Though adoption is presented as a “method”,

even the “best”, among other methods of addressing infertility, it is discussed only after all the other methods are discussed. Adoption is premised on a very different idea of family. As Shah (2009) points out:

> ARTs, however, underline the importance of genetically linked families. In that sense, they provide individual solutions to a wider social problem. By feeding into the normative notions of family and support, they necessarily weaken all struggles to redefine the problem itself (p. 32).

Merely listing adoption as a method to address infertility does not serve any justice to the concept, as it bases itself on an alternative understanding of the nature of the family—based on social relations as opposed to genetic relations.

3.7 Discussion

This analysis suggests that the textbook's latent function seems to be that of serving the state agenda of reproductive control of its citizens, particularly women, through the use of technology as manifested by its celebration of the population control policy as well as the discussion of fertility enhancing technologies with limited scope to questioning its role in reinforcing patriarchal notions of genetic parentage. Regardless of the history of strong resistance to these technologies by the women's health movement, contraceptive and fertility enhancing technologies are discussed through dry descriptions. Importance of the knowledge of the menstrual cycle and the efficacy of natural and less invasive contraceptives are underplayed while chemical and more invasive technologies are celebrated, paying only lip service to serious side effects associated with these technologies. There are no possibilities to question the very need of these technologies. One of the professed aims of the curriculum at this stage is to create future scientists, technologists and medical practitioners (providers of these technologies). This was also echoed by the textbook writer when he mentioned that one of the aims of the chapter was to introduce students to 'applicative dimensions'. In relation to this aim, the absence of any discussion on side effects of the various contraceptive and fertility technologies is worrisome because it implies that the users’ perspective or experiential meaning of the technology does not matter in a curriculum catering to the providers of these technologies. The text also promotes technocratic solutions to birth control and fertility

assistance suppressing the socio-political dimensions pertaining to these aspects. Thus, values motivate decisions on what should qualify as 'content' in the textbook.

Thus, a critical examination of the scientific discourse on the topic of reproductive health convinces us that as long as the curriculum and textbook writers view the science curriculum as a purveyor of facts alone, there is a danger of certain mainstream values being communicated through the curriculum in an authoritative manner and that it is important for science textbook writers as well as teachers to critically examine, make explicit and justify the value frameworks that they use to write 'facts' or teach 'facts' in the science textbook.

In the light of this critique, we need to ask how an alternative portrayal of the topic of reproductive health would look like. This alternative would firstly recognize that health is a political matter and is linked to unequal distribution and access to basic resources. It would raise questions regarding the reproductive health of all individuals in society, whether the health of one group of people is achieved at the expense of others and critically discuss reproductive ailments in their larger social, economic and political context. It would also raise critical questions regarding the technologies being discussed: Are these required at all? Are they safe? Can they be accessed by all? Or only by the few who can pay for them? Whose bodies are these technologies targeted at? Are potential users of these technologies capable of exerting a choice on how and when they want to use these technologies? Besides, the curriculum would enable students to conduct inquiries on the safety dimensions of these technologies, helping them to understand the tentative nature of evidence associated with risk assessment. The curriculum would also make explicit the nature of science underlying the design of technologies that are aimed at interfering with the reproductive system, emphasizing the interconnectedness of facts and values and helping students understand that alternative values may lead to a different understanding of the body and consequently, the design of different kinds of technologies.

PREFATORY NOTE TO CHAPTERS 4 AND 5:

STUDY WITH HIGHER SECONDARY BIOLOGY STUDENTS ON SOCIOSCIENTIFIC ISSUES

While in the last two chapters (Chapters 2 and 3), I present an analysis of a higher secondary biology textbook and the national curriculum documents with regard to the manner in which they present STS concerns, in the following two chapters, I focus on the ways in which higher secondary students engage with a socioscientific issue introduced to them in an informal, out-of-school context. As discussed, key findings from the analysis of the class XII biology textbook indicate that value conflicts around various controversial topics are not appropriately represented and less attention paid to developing the skills needed for students to evaluate risks surrounding various technologies. This in turn led me to an exploration of how higher secondary biology students negotiate SSIs, given the absence of any formal educational exposure that would render them the skills to engage with these.

As elucidated before, Hodson (2003) suggests that an issue-based curriculum might best help to realize the goals of CSL, advocating potential themes around which politicization of the curriculum may be achieved. Some of these include health; land, water and mineral resources, food and agriculture, industry, energy resources, IT and transportation and ethics. Pedretti & Nazir (2011) point out these issues could either be derived from the immediate context of the learner, where they engage in solving problems that are local to the community or these could be more general issues such as global warming and climate change.

Plenty of research has been devoted to investigating the ways in which students "negotiate" socioscientific issues with a focus on the role of different factors involved in reasoning and argumentation (Hodson, 2011; Sadler, 2004). Nonetheless, researchers' understanding of *what constitutes negotiating SSI*, as argued before, depends on the degree of technocraticity they attribute to the relationship between science and society (Levinson, 2007). Technocratic perspectives of science-society interface tend to perceive a rigid boundary between science and society and a deficit view of the publics' ability to engage with science. In this model,

scientific knowledge and consequently, scientists/technocrats are viewed as being the sole arbitrators when negotiating a socioscientific issue, while less technocratic models view the science-society boundary as being essentially porous, viewing the relationship between science and the public as tense and power-ridden. They also lend credence to non-scientific knowledge (experiential, anecdotal knowledge) in resolving a socioscientific issue. Thus, if one discusses how students negotiate a socioscientific issue, one cannot do so without acknowledging one's position in this theoretical-ideological landscape, as this would determine what factors one chooses to focus on when analyzing students' negotiation of these issues. This thesis also adopts a less technocratic approach to understanding the science-society interface (Raveendran & Chunawala, 2013). As mentioned, my reasons for doing so stem from the feminist, critical perspectives I adopt towards science and science education research.

Hodson (2003) highlights the importance of using problems and issues related to technology in fostering critical scientific literacy -- being “all pervasive” in the western world, the values surrounding them are constantly discussed in the print and visual media. Allchin (1999) discusses how technologies can either raise new ethical and social dilemmas based on pre-existing values or challenge them more directly. He illustrates this with examples of technologies like hemodialysis and organ transplantation technology which sustain the value of preservation of life or health but raise new values on equitable access while the new reproductive technologies challenge values more directly by complicating the concept of parentage. Hodson further argues that it is therefore easier to see how socio-cultural context impacts technology and vice-versa than science but he also underscores the fact that using issues related to technology “is not an argument against teaching science; rather, it is an argument for teaching the science that informs an understanding of everyday technological problems and may assist students in reaching tentative solutions” (p.655). He points out that a politicized science curriculum rejects the notion of technological determinism and students ought to be empowered to make choices on what technologies they will or will not use. Following this, I chose socioscientific issues around controversial technologies for my work with higher secondary students biology students where they were introduced to five issues related to controversial medical technologies which were reported in the media around the

time I conducted my fieldwork in 2011-2013. These include paid kidney donation through living donors, Sex change operations for transsexual individuals, Ultrasound technology and its use in diagnosing disabilities, IVF technology and Commercial surrogacy, and the use of Euthanasia for patients in permanently vegetative state (PVS). These issues are contentious at various levels, and include differences related to nature of evidence, ethical differences, interest positions and worldviews.

The issue of legalizing paid organ donation involving live organ donors[13] is controversial and has been discussed in the Indian media. Scientific evidence on health risks for organ donors may be important when negotiating the issue (Goyal, Mehta, Schneiderman, & Sehgal, 2002). Participants may debate on ethical issues around the desirability of commodification of organs. Their views on the issue may also stem from deep rooted personal experiences (of say family members who have undergone kidney transplantation) or the interest positions they assume regarding the issue in terms of their sensitivity towards various stakeholders. The issue also further raises questions on equitable access, and larger social justice questions of exploiting poverty (Phadke & Anandh, 2002, Sayeed, 2009), for if paid organ donation is legalized, it would invariably be the poorer sections who would offer their organs for sale.

For a long time now in India, commercial surrogacy[14] has been in the news. India has become a hub for reproductive tourism what with poor willing surrogate mothers willing to lend their wombs at affordable rates. Similar to the issue on organ donation, this issue as well raises similar questions on safety of the procedure for surrogate mothers and biological mothers as well as social justice (Shah, 2009). Value positions on whether biological motherhood is such a valuable end in itself may also be debated. Scientific evidence on safety of procedures and success rate of IVF procedures may be important on taking positions on the issue.

The issue on ultrasound technology and disability was structured around a case that happened in India in 2008 - Popularly known as the “Niketa Mehta Case”[15]. Niketa Mehta and her husband moved to the Delhi High Court against the Medical Termination of Pregnancy law which mandates that abortion is illegal after 20 weeks after they found out through a medical ultrasound that their child to be born would suffer from a congenital cardiac disorder. This

13 http://www.wired.com/medtech/health/news/2007/05/india_transplants_main?currentPage=all
14 http://www.nytimes.com/2011/10/05/world/asia/05iht-letter05.html
15 http://www.indiatogether.org/2008/aug/ksh-mtpchoice.htm

case sparked an almost non-existent debate in public forums on abortion as well as disability rights in the country, revolving around the question of whether parents should be invested with the right to abort fetuses with severe disabilities. The issue hinges around the ethical debate on the right to life versus the right to a life free from pain. The debate may be informed by scientific knowledge (aspects such as typical lifespan of an individual with the concerned disability), as well as anecdotal knowledge of disabled people as well as caregivers on the nature of various disabilities and what it is like, on a day to day basis to live with these issues. According to Madhiwalla (2008), in the Indian context, the abortion debate has, in some sense, been over-shadowed by the sex-selection debate. She discusses the complexities of the issue wherein a woman's right to a free choice on abortion may be challenged from the point of disability rights, pitting the feminist and disability movements against each other.

Students also discussed the euthanasia debate which was structured around the “Aruna Shanbaug”[16] case. Shanbaug, a nurse by profession, was bed-ridden and in a coma like state characteristic of patients with PVS for 37 years after being subjected to a brutal sexual assault by a colleague. In 2011, a journalist who visited her and witnessed her plight filed a petition in the Supreme Court seeking euthanasia. The case opened up a debate on euthanasia in the public forum. Similar to the disability issue discussed above, the ethical differences on value of life and right to a life free of pain might be a matter to consider while considering the issue. Scientific knowledge on the nature of PVS state and its diagnosis may inform negotiation of the issue. In both the euthanasia and abortion case, participants may bring in viewpoints informed by personal experiences on caring for individuals with disability.

In early 2012, a case[17] on sex change operations opened up a debate on gender and sexuality in the Indian media. Bidhan Baruah (now Swati) filed a petition in the Mumbai high court seeking to change his sex to a female. The issue brought to fore questions on the rights of the LGBT community to practise sexuality/gender of their choice. This is in turn revolves around questions of whether alternative expressions of sexuality need to be considered as 'disorders', the role of science (Levinson, 2010) and religious doctrine in legitimating this view.

What is common to all the issues are that they have inherent in them aspects of

16 http://articles.timesofindia.indiatimes.com/2012-05-13/india/31689540_1_surgery-plastic-surgeon-gender
17 http://www.ndtv.com/article/india/aruna-shanbaug-case-supreme-court-rejects-euthanasia-plea-89894

violation/disregard of the rights of one group of people by the other. While the issues of paid organ donation and commercial surrogacy raise concerns regarding the exploitation of the poor's need for money, the abortion and euthanasia issues revolve around the right to life and death of disabled individuals. In both the cases, able-bodied individuals make decisions for individuals with impairments. The resistance to sex-change operations stem from transphobia and prejudices towards the LGBT community, the root of which is nurtured by science and religious doctrine. Although all the issues have a scientific or technological dimension inherent in them, negotiation of these issues require drawing on values in addition to scientific evidence.

For the purpose of this thesis, I have chosen to focus on just one of the issues that have been mentioned above, which is IVF and commercial surrogacy. Chapter 4 and 5 discuss the social, ethical and political concerns and the epistemic skills respectively that students bring to bear on the negotiation of this socioscientific issue.

CHAPTER 4

STUDENTS' NEGOTIATION OF COMMERCIAL SURROGACY: ETHICO-POLITICAL AND EPISTEMIC CONCERNS

4.1 Overview of the Chapter

Chapter 3 leaves us with the kind of questions an educational experience that brings in ethical and political concerns in the discussion of reproductive technologies would look like. As pointed out, the class XII biology textbook discusses IVF, albeit in a dry, technical manner. A real life, contextualized socioscientific issue like commercial surrogacy brings out the human dimensions related to the technology. Negotiating the issue would involve the consideration of a complex range of factors. This chapter reports an exploratory study that investigated the social, ethical, political and scientific value considerations that higher secondary biology students brought to bear on commercial surrogacy – an SSI that relates to the technology of In-Vitro-Fertilization (IVF).

4.2 Research on socioscientific issues: a brief review

A predominant focus of the research done on students' negotiation of socioscientific issues in the past one decade has been on the nature of argumentation that students bring to bear on their discussions of socioscientific issues. Among these, many have adapted frameworks such as Toulmin's argumentation pattern (TAP) (Kolstoe, 2006) and Deanna Kuhn's informal reasoning (Sadler & Zeidler, 2005). These studies have focused on students' abilities to sustain arguments, which involves being able to support their claims with data, providing adequate warrants, constructing counter arguments, rebuttals and so on. The widely used TAP, however, has been found to be limited (Erduran, Simon & Osborne, 2004; Hodson, 2011; Levinson, 2013; Nielson, 2013b). Erduran et al (2004) note that researchers run into

difficulties when extrapolating the core elements in TAP – data, warrants, rebuttals and so on, often confusing between them. Nielsen (2011) elaborates further that extrapolating the core elements from arguments using TAP involves a lot of interpretation the part of the researcher as it happens within larger discussions which are dialectical in nature. This is often not made explicit in many studies. Further, Levinson (2013) notes that hierarchical scoring of arguments defeats the whole purpose of engaging students in socioscientific issues – which involves democratic deliberation based on values which are socially and culturally embedded. This brings us to the point that Nielsen (2013b) makes forcefully, that socioscientific deliberations revolve around what to do; not what is true because very often values, and not scientific concepts or evidence are what drive deliberations on these issues. There is, therefore, a need to focus on the argumentative and rhetorical strategies that opponents adopt in their discussions on these issues, as opposed to using normative frameworks such as TAP to measure the quality of arguments, which involve judgments on the part of the researcher that are made very often on the basis of non-explicit assumptions. Though a few studies have begun to start addressing these limitations employing alternative frameworks (Nielsen, 2012) that base themselves on in-depth qualitative approaches, the field is still nascent and a lot more work needs to be done. Above and beyond the limitations of these frameworks, an important fact remains that human beings very often do not communicate in what Levinson (2007) calls the *logicoscientific* mode (which frameworks like TAP attempt to capture). Individuals most often employ a *narrative* mode of communication which involves a telling of stories, where they bring in personal experiences and anecdotes to make sense of an issue or even, illuminate their position. Although, for my work as well, I set out thinking that I will examine the argumentative strategies that students employ in their discussion of socioscientific issues, I realized, for the reasons reviewed above, that it may not really yield useful results.

A second line of research looks more closely at the various considerations that students bring in when negotiating SSIs – moral and ethical concerns, conceptual knowledge of science, nature of science, evaluation of evidence related to SSI, to name a few (see a reviews by Sadler, 2004 and Hodson, 2011). For the purpose of this chapter, I will proceed to a discussion of the research that has examined students' moral and ethical considerations.

According to Pedretti and Nazir (2011), research focused on the moral and ethical considerations that students employ in their evaluation of SSIs involve two kinds. One strand of research has looked at the kind of ethical frameworks students use in terms of the different schools of thought such as deontology, consequentialism, virtue ethics and so on (Reiss, 2008). The second strand has explored ethical arguments from a moral development framework (Zeidler, 2005) as well as investigated the role of emotions and intuitions in reasoning (Sadler, 2004b; Sadler & Zeidler, 2004; Sadler & Donelly, 2006). In this chapter, I discuss students' ethical positions in terms of certain principles in bioethics, which include autonomy, beneficence, non-maleficence and justice.

I would like to emphasize here that I am wary of pluralist positions on the moral or political positions with regard to socioscientific issues that do not discern between these positions or evaluate them in any way. I agree with Levinson (2013), who, in an incisive critique of existing research in socioscientific issues points out that there is an excessive focus on individual “decision making”, often with disregard to where these individual decisions stand vis-à-vis the larger socio-political structures:

> ...what good decision-making might look like, and how it might take place, in neoliberal-dominated societies approaching upheaval – environmentally, economically and politically – where the logic (or madness) of the markets is in tension between both individual and communal well-being, political reform and curriculum framing. (p. 100)

This analysis will reflect a constant evaluation of students' ethical and political standpoints in terms of how far they stand from ideals upheld by critical science education – equity and social justice. This, for me, translates into adopting a strong position against patriarchal, capitalist, racist and casteist discourses. This is not to say that I do not value or reject what individual students brought into their discussions, but I believe that SSIs are inherently political and researching as well as teaching these issues happen from a political standpoint. There is, therefore, a need for teachers as well as researchers to lay out their political positions vis-à-vis these issues when they engage in studying or assessing students negotiation of these issues.

4.3 Theoretical position

The socioscientific issues movement emerged in response to the perceived limitations of the STSE approaches, which were seen as diffuse and theoretically under-evolved. In Zeidler et al.'s (2005) words:

> Traditional STS(E) education (or perhaps STS(E) education as currently practiced by and large) only “points out” ethical dilemmas or controversies, but does not necessarily exploit the inherent pedagogical power of discourse, reasoned argumentation, explicit NOS considerations, emotive, developmental, cultural or epistemological connections within the issues themselves (p.359).

Though I have not engaged in an in-depth analysis to verify whether the above statement regarding traditional STSE education is indeed true, I am in agreement with the views of the authors that explicit attention to factors such as discourse, argumentation, NOS and ethical dimensions of socioscientific issues need to be paid attention to and engaging students in negotiation of SSIs is important. However, I also agree with Hodson (2011) when he says that “neither STS nor SSI-oriented teaching go far enough” (p.31) and Levinson (2013) who point out that the current frameworks predominant in socioscientific issues research is individualistic, focusing more on making students better decision makers, at the expense of inculcating a will to work for common good or larger societal well being.

Levinson's argument is particularly important in understanding socioscientific controversies in a developing country like India, where the political component inherent in these issues becomes almost impossible to ignore. Varughese (2012), for instance, points out that although the overt rhetoric that has captured the public imagination in India equates science and technology with development and progress; technoscience, state and industry work hand in glove to reinforce oppressive structures like caste, class and patriarchy. The harsh reality is that stakeholders involved in negotiating a socioscientific controversy are rarely on a level playing field. A case in point are the many controversies around state-backed science and technology based development projects that have displaced and then failed to deliver justice to large sections of the poor and downtrodden, where respectful discussions or deliberations fail to occur between the stakeholders. Theoretical frameworks, therefore, need to

acknowledge the political component inherent in these issues. Most of the existing research around SSIs are preoccupied with using socioscientific issues as a context to enhance science content knowledge and develop skills such as evidence evaluation, argumentation, moral reasoning, and so on (Sadler, 2004a; Sadler, 2004b). However, the excessive focus on skill development has lead to a reductionist treatment of the SSI itself and the complexities inherent in it.

Consequently, for students to better engage with these issues, they need to become politically literate as well. Levinson (2010) provides further direction as to how we should understand political literacy in relation to socioscientific issues, pointing out that the way we conceptualize SSI education is closely tied up with the notions of democratic participation we believe in. The notion of critical scientific literacy would presuppose an understanding of democracy as a pluralist system or a deliberative democracy - a political order where there is struggle and dissent between different ideological viewpoints as opposed to an understanding of democracy as consensus building, presupposed in notions of functional scientific literacy (Zeidler et al., 2005). In a critique of consensus building approaches, Levinson (2010) points out:

> But there are quite notorious examples where the forums of deliberative democracy have simply not been available to those who suffered from accidents such as the leak of methyl isocyanate from the Union Carbide plant in Bhopal in 1984, the Tuskegee syphilis scandal or the biopiracy of the Neem tree in India (Shiva, 1997). While striving to achieve justice constitutes a central theme of democratic deliberation, it does not follow that justice will be achieved when the suffering parties feel the odds are stacked against them. Dialogue is simply not seen as an option. Where reasonableness and calm are seen as the virtues in liberal formulations of deliberative dialogue, feelings of outrage and injustice can become a barrier and exclusionary.

One cannot presuppose, therefore, that contending parties can, in a straightforward manner, resolve and come to a consensus on SSIs. Consequently, there is a need to move one's focus beyond the moral dimensions, to the political dimensions inherent in these issues. Levinson (2010), for instance, astutely remarks on why, when considering a socioscientific controversy,

there is a need to:

> ... distinguish between political adversaries and moral enemies , recognizing the former as constitutive of the hegemony of social relations, and the motivations for hegemonies to defend their own interests, is distinct from arguments from personal perspectives over right and wrong. (p.104)

A major challenge, therefore, has been to identify appropriate theoretical frameworks that can accommodate the political dimensions inherent in socioscientific controversies. One framework that has proved useful is Levinson's (2006) epistemological framework with which one can parse out what is controversial in an SSI. This framework leaves scope to identify the political dimensions inherent in these issues as well. Besides, it is premised on a non-technocratic model of understanding the science-society relationship that legitimates the role of different sources of knowledge in negotiating the issue. This framework parses out what is at stake in an SSI in terms of multiple, mutually interacting *Levels of reasonable disagreement (LoDs).* These in turn make explicit what is at stake in an SSI in terms of evidence, values and world-views. There are 9 LoDs. The direct role of evidence in resolution of the disagreement diminishes as we move from level 1 to level 9. Concomitantly, other aspects like differences in ethical premises, view-points relating to personal experiences, indeterminacy of concepts and differences in world-views become the sources of contention, rather than evidence alone. The levels are not hierarchical. When a socioscientific controversy is examined through the lens of this framework, one is able to assume multiple standpoints on it in terms of the lived experiences and vantage points of different participants, as opposed to assuming a universal structure to these controversies that are independent of the people involved or the contexts they come from. In the section that follows, I unpack the issue of commercial surrogacy on the basis of Levinson's Levels of disagreement.

4.4 Issue used for the study

Herein, I discuss commercial surrogacy, a topical and controversial issue often reported in the media. In simple terms, a gestational surrogacy arrangement in IVF procedures involves the carrying of pregnancy by a third person (a woman) when the biological parents who, due to biological reasons are unable to do so or simply choose not to carry a pregnancy for other

reasons. When this becomes an economic arrangement between the biological parents and the gestational mother, it is referred to as commercial surrogacy. In India, the fertility industry is a highly profitable industry and many poor women opt into it as it is financially lucrative and brings some reprieve to their abysmal living conditions. The technology is known to pose severe health risks to users – both the surrogate as well as biological mothers (Shah, 2009). The fertility industry, at the time I was conducting my fieldwork in 2011-2013, was largely unregulated in India, though a draft version of the Assisted Reproductive Technologies bill, that lays down guidelines to regulate the use of the technology, was drafted back in 2010, and has undergone various revisions since. Very recently, in 2016, a controversial surrogacy bill has been drafted which seeks to ban it completely.

The issue of commercial surrogacy and its purported role in addressing infertility as well as being a magic bullet remedy for poverty is controversial and has been subject to excessive deliberations in the media as well among feminist academics. Feminist critiques of reproductive technologies have raised pertinent questions on surrogacy – primarily in terms of whether it is an empowering option for poor women taking into cognizance the risk it poses to their bodies (Shah, 2009) as well as the question of whether it is really a "free choice" that the surrogate mother is making[18], because, a) the choice is most often made under economic compulsions and b) because a surrogate mother might not be scientifically literate enough to comprehend the nature of risks, given her educational background.

The issue of commercial surrogacy can be unpacked on the basis of Levinson's Levels of Disagreement[19] (Table 4.1). At levels 1 and 2 issues related to evidence may be deliberated. Health risks to the surrogate mother, biological mother, and success rate of IVF procedure may be debated at these levels. Evidence related to socioscientific issues is complex, conflicting and difficult to assess and may not be conclusive. Those deliberating on the controversy at these levels need skills to evaluate multiple sources of evidence, assess reliability of claims, identify biases and so on. But it is also important to remember what Allchin (1999) points out, "Scientists (or science) can accord where, how and to what degree a risk exists, for example. But other values are required to assess whether the risk is acceptable or not" (p.7). Hence those engaged in debate at this level would also need to

18 Sadath Sayeed (2009) discusses this issue in an article where she debates the ethicality of kidney trading.
19 I discuss all levels except level 7, as Levinson subsumes it under level 9.

understand that in the face of inconclusive evidence, other “non-scientific” values play an important role in making decisions on these issues.

At level 3, participants engaged in the debate may broadly agree that a particular criterion is important in making a decision on the issue, but may differ on how much priority needs to be given to that criterion. For example, participants may agree that IVF should be available to any user who may wish to utilize it, but they may differ on universalizing the access of the technology and making it affordable to all. These differences may be based on factors such as cost, interest position, cultural values, and so on. At level 4, debating participants may differ on ethical premises on the basis of which they make judgments on the issue. For instance, participants may disagree on whether it is right to commodify a body or rent a womb. They may also disagree on whether it is really necessary to have one's own biological child which in turn hinge on questions of genetic and social parentage. Very often, in India, women are forced to make use of these dangerous technologies because of the primacy that Indian culture attributes to blood relations and ensuring genetic lineage (Bharadwaj, 2003).

At Level 5, disagreements are related to differences in the interpretation of concepts involved. For example, participants in a discussion may differ on what they understand by a “parent” - wouldn't the surrogate mother also qualify as a parent even if she is not contributing genetic material? Another example of a level 5 disagreement would be whether surrogates are actually making a 'choice' to rent their wombs? Is a choice motivated by poverty a free choice and so on. At level 6, students may disagree with each other on account of the differing interest positions that they adopt towards the issue. To elucidate what he means by interest positions, Levinson uses an example of an SSI which involved the proposal to shut down a nuclear power plant due to radiation related concerns. Employees of the power plant may want to stall the proposal because their jobs would be at stake, while residents would be more concerned about potential health risks. Since their interests conflict, both the parties are drawn into a conflict with each other. In terms of the issue of commercial surrogacy, we operationalize interest positions to mean the kind of associations or affinities that students adopt with regard to the different participants involved in IVF - the biological parent, the surrogate mothers or the IVF baby. Students who adopt an interest position in favor of the biological parents may not consider questions like whether the technology is causing harm to the surrogate mother or

maybe wary of the surrogate mother, while students who adopt an interest position in favor of the surrogate mother may be concerned most about her safety. This is an important level of disagreement as far as understanding the political dimensions of the controversy is involved.

At level 8, students may have very crucial personal experiences that may influence the way they approach the controversy. For instance, a participant who is adopted or have a close relative or friend who is adopted may approach assisted reproductive technologies differently from someone who is not. At level 9, participants differ due to competing worldviews or different frameworks of looking at the world. For example, a participant who is religious may evaluate assisted reproductive technologies from a different vantage point than someone for whom religion is not a major influence. In the next section, I proceed to discuss the details of the empirical study that was conducted to investigate students' negotiation of commercial surrogacy.

4.5 Methodology

4.5.1 Participants

The participants of the study involved 20 science students of Class XII (12 studying with the Central Board of Secondary Education and 8 with the Maharashtra State Board) as well as group interactions with 19 class XI students (Figure 4.1). The students were roughly 16-17 years of age. In both the schools, the medium of instruction was English. All students had opted to specialize in biology and studied in a large government school system that catered to the children of the nuclear establishment. The students varied considerably in their socioeconomic background[20] as well as linguistic background (they came from different parts of the country) The reason why this particular group of students was chosen was because they constitute a sample who has undergone 10 years of compulsory education in science and are also still motivated and excited by biology to choose it as their specialization afterwards, though anyone who has a general education in science up to class 10 should be equipped to engage with these issues. It follows, therefore, that their competency in engaging with these issues will have implications even for science education up to class X, as their skills in

20 There was a great disparity in the income of the students' families depending on the kinds of jobs their parents engaged in at the nuclear facility.

negotiating these issues are indicative, to a large extent of what they learned in school up to class X. Both the interviews and group discussions were carried out in English[21].

4.5.2 Probes used for the study

The probes used with the students involved a written description of In-Vitro-Fertilization along with questions. The written description on IVF used for the interview and initially used for the group discussions were similar (refer to Appendix V-IX for the instruments used in individual interviews as well as group interactions). The validity of the tool was established through a series of iterations that involved pilot testing and peer debriefing on the pilot data. The finalized tool was also used on a sample of 12 students from class XII who had chosen commerce as specialization. These students, despite being from a non-science background were able to engage with the tool satisfactorily.

4.5.3 Interviews

The interview method adopted in this study would fall within the tradition of active interviewing. This approach views both the interviewer as well as respondent as active constructors of meaning engaged in a dynamic interaction. According to Holstein and Gubrium (1996), the traditional modes of interviewing view the respondent as a passive "vessel-of-answers" whose experiences are bottled up within them, waiting to be prospected by the interviewer, who through the correct application of procedure draws them out. Within this paradigm, there is a concept of "polluting" the interview, wherein the interviewer has to tread carefully to not lead the respondent into answering responses that she wants to hear. This assumes a lack of agency in the respondent, who can only assent. Active interviewing, on the other hand is premised on a very different conception of the interviewer-respondent relationship. While the active interviewer "intentionally provokes responses by indicating – even suggesting – narrative positions, resources, orientations and precedents" (p.123), the respondent "not only holds facts and details of experience, but, in the very process of offering them up for response, constructively adds to, takes away from and transforms the facts and

21 Most participants were comfortable in English and Hindi. The interviews and discussions were conducted primarily in English because I was more comfortable speaking in the English language, albeit they were never discouraged from speaking other languages. They often resorted to Hindi or mixed Hindi words while they were engaged in discussions.

details" (Holstein & Gubrium, 1996, p.117). Through this process, both the interviewer and respondent actively co-construct meaning.

Twenty students of Class XII were interviewed. There were two parts to the interview: the first part introduced the student to the issue (clarifying the factual dimensions pertaining to the technology), the second introduced students to a specific dimension of the debate and elicited their opinions on it (refer to the Appendix V). I chose to focus on the social inequality dimensions pertaining to the issue in part 2 of the interview. The interviews were audio-recorded and transcribed. Participants in the interview have been denoted as P_n, "n" denoting the participant number.

4.5.4 Group interactions

Group interactions with students were carried out to circumvent the perceived limitations of interview data – it was felt that students may not have opened up as much in interviews as they would in an informal setting that involves other students where they can freely interact with each other. The group discussions were conducted in two batches of class 11 students, 10 months apart. A batch of of 6 students in 2 groups, and another batch of 13 students in 5 groups interacted with each other as well as the researcher in a meaning making context. A probe similar to the one used for the interviews was used for the group interactions. Participants responded to the questions individually by recording their responses in worksheets (Appendix VI-IX). Thereafter, they were encouraged to discuss their responses in student-only groups (groups of three or more that they formed based on their preference). Subsequently, each student group presented their responses to the facilitator in a whole group discussion. The facilitators, in the group discussions, primarily elicited their views on the various questions posed, and occasionally played the role of devil's advocate to gain a sense of how students' defend their opinions. In line with principles of feminist research (DeVault & Gross, 2007) and social constructionist approach (Holstein & Gubrium, 1999) we are open to the possibility that our own views, the manner of framing questions etc may also have influenced the course of the discussions. The group discussions were video-recorded and transcribed. All the whole group discussions have been transcribed and analyzed. A few of the student group discussions have also been transcribed and analyzed (based on the audio-

quality). Participants in the group discussions are denoted as Gd_x P_n where X= batch 1 or 2 and n stands for participant number.

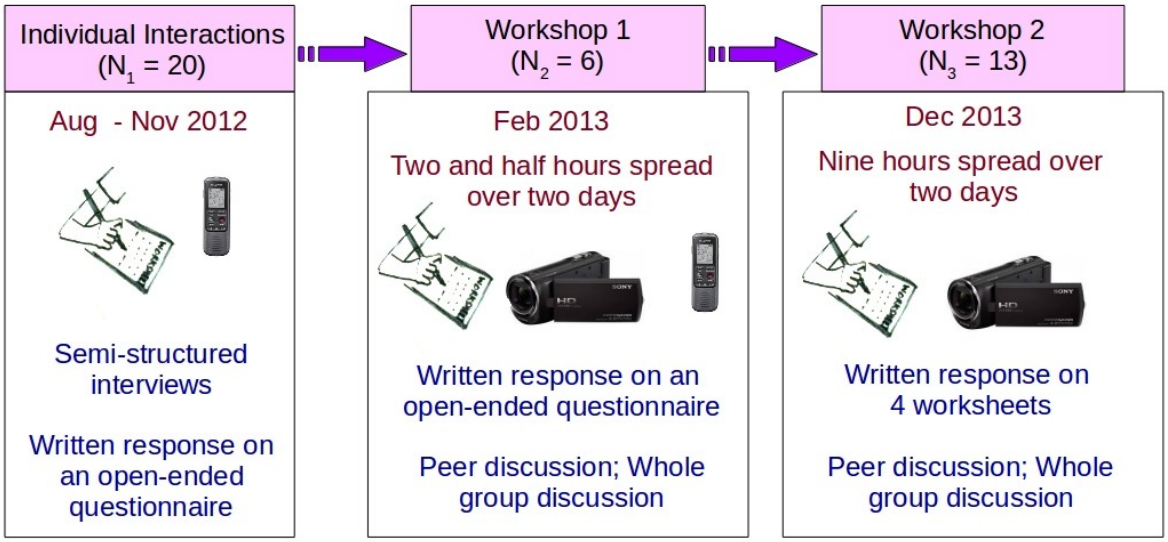

Figure 4.1 Study design

4.6 Results

The data analysis involved categorizing the sociopolitical, ethical and epistemic considerations that students raised as well as the standpoints that students adopted when discussing the issue. A grounded theory approach was employed, where the transcripts of the interviews as well as the video data from the group interactions were examined thoroughly and coded. A constant comparison method (Strauss and Corbin, 1998) was used where an initial chunk of the data was coded into broad categories, followed by checking and adjusting subsequent portions of the text to the initial codes. The initial codes that were developed were shared with a co-researcher and refined. As regards validity, establishing it quantitatively through inter-rater reliability did not seem right, for there were specific dimensions to the context that an independent coder may not grasp (Campbell, Quincy, Osserman and Pederson, 2013). However, after coding, the codes and data were shared with a group of researchers and their interpretations on the fit sought. To facilitate reader evaluation, large chunks of data have also been presented (Madill, Jordan & Shirley, 2000).

While discussing commercial surrogacy, students raised various ethico-political concerns as well as epistemic concerns regarding the technology (see Figure 4.2). In the section that immediately follows, I will first elaborate these concerns. I then turn to a discussion of the standpoints that some students adopted when discussing an issue which were either people-based or principle-based. From the point of view of critical science education, the standpoints adopted by the students in terms of the stakeholders are important, for it evinces their ability to evaluate the technology on the basis of different users of the technology. To illustrate each of the categories, I have presented supporting data from the interviews, worksheets or classroom discussions which have been labeled as extracts.

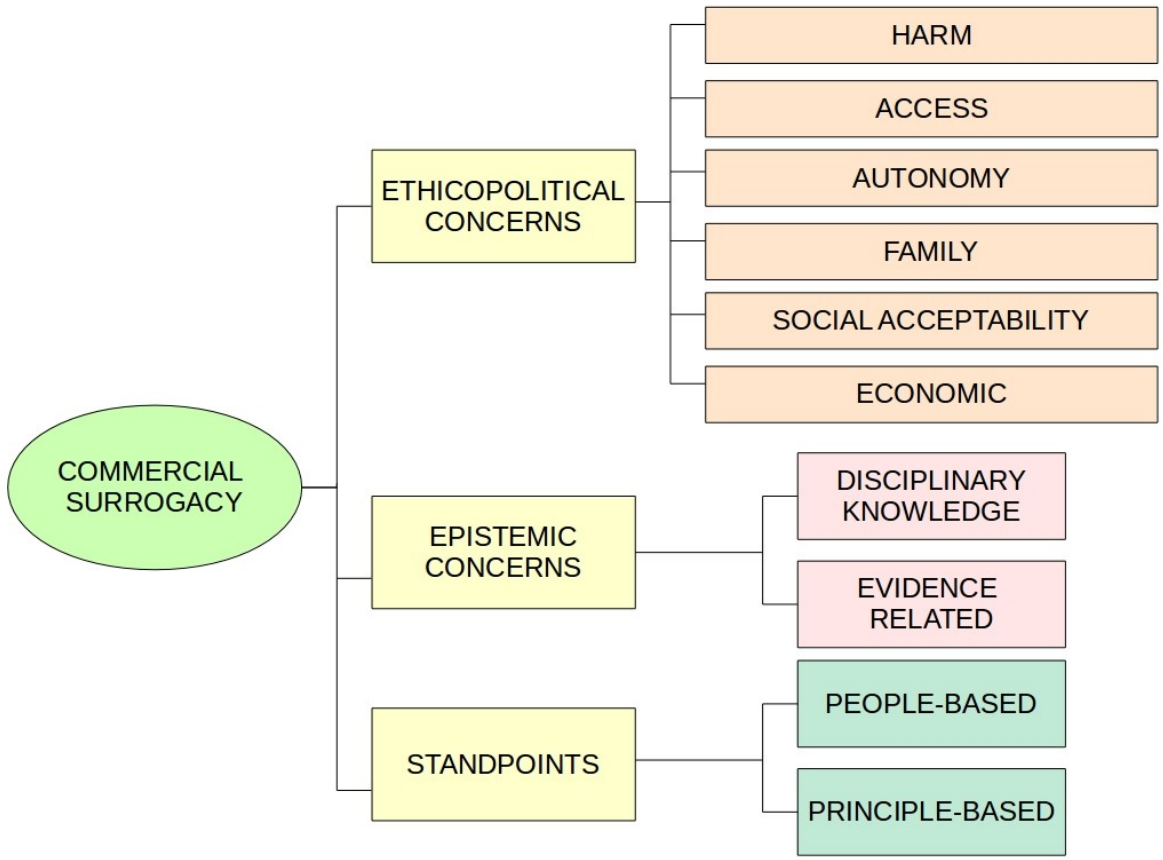

Figure 4.2 Ethico-political and epistemic concerns raised by students

4.6.1 Ethico-political concerns

Ethico-political concerns have been broadly grouped into concerns related to harm, concerns related to access, concerns related to autonomy and choice, concerns related to the nature of the family, concerns regarding social acceptability of the surrogate mother and economic concerns. While the first three of these concerns invoke foundational principles of bioethics – autonomy, non-maleficence (concerns related to harm), and Justice (concerns that discuss access); the concerns pertaining to the nature of the family and the social acceptability of the surrogate appear to stem from underlying worldviews. In the section that follows, I elaborate these.

a. Concerns related to harm

Harm-related concerns in the students stemmed primarily from an ethical concern regarding whether the technology poses health risks to any of the individuals interacting with it. This indicates reasoning based on moral principles that are concerned about minimizing harm, or what is referred to as the principle of non-malificience in bioethics (Gillon, 1994). Many students among those interviewed referred to harm – both emotional and physical – that the procedure would pose to different stakeholders involved.

About 16 out of 20 students raised concerns regarding potential harm the technology would pose to the surrogate mother in the interviews, despite the question being framed from the standpoint of the biological parents: *"Do you feel that it is okay for people to opt for this technology to have children of their own? Why or why not?"* A few students (three) also raised concerns regarding the health of the baby born through the procedure. However, queries and concerns pertaining to the impact of the technology on the health of the surrogate mother were maximum. A typical response in this category is as follows:

EXTRACT 1

> ...if the surrogate mother is … umm ... if the uterus is used continuously… the body will lose its vigour and vitality.. (P_{17})

EXTRACT 2

> It (IVF) is of course a good method because if a mother can't get a child, she has

> no other option. But for the woman who is carrying the child, she has to undergo hormonal changes and all... so...I think both the ways we can say (P_8)

The following is a response indicating concern for the health of the child to be born :

EXTRACT 3

> ... the hormonal changes (that) come in (the) women's body ... in a surrogate mother, corpus luteum and all..in feeding also ..the first milk provide(s) immunity to the child....that immunity will be provided by surrogate mother (and) is not (provided) by the original mother..half of the the sperm and egg will be provided by biological parents but milk will be provided by surrogate mother..the immunity and all.. (P_2)

In the worksheets used in group discussions, students were explicitly directed to think about the technology in terms of the perspectives of different people involved in a surrogacy arrangement which includes the biological parents as well as the surrogate mother. In their written responses, nine out of nineteen students who participated in the group discussions raised concerns regarding whether the technology will adversely impact the surrogate mother. For example, a girl wrote:

EXTRACT 4

> ... Making decision(s) on such a big thing is difficult for which we need to know about the difference that we can find in naturally producing child and artificially and their side effects. (GD_2 P_{11})

Participants also weighed the perceived harm caused by the technology vis-à-vis other concerns, such as economic gains, pointing out that as long as some condition is satisfied, poor women opting for the technology is not so bad, as in the exchange below:

EXTRACT 5

Interviewer :	Again many people think that it (commercial surrogacy) should not be allowed because it encourages only poor women to come forward.
P_3 :	But I think so ... here it is given that they earn one lakh per pregnancy. Not just the money but [inaudible]..(the surrogate) mother should be taken care. Most of the pregnancies are taken care fully but I think so if in future if because of that pregnancy she has some complications and it may affect her life anyway... So the parents should support her and help her. Because for their wish they are risking her life..

In the above case, the student believes that as long as the surrogate mother's health is taken care of by the biological parents, it may benefit her to make these choices because she gets financially compensated for it. This exemplifies a case where the student prioritizes economic considerations over health concerns in her cost-benefit analysis. Four other students in their interviews displayed similar patterns of reasoning.

Seven students who attended the workshop appeared to be weighing health and financial considerations in their written responses. e.g.:

EXTRACT 6

> I think being a surrogate mother is a good source of employment for poor women as they can earn a large sum of money just by carrying a pregnancy and giving birth to a child. This will be like carrying her own child. But I am not clear about the consequences on the body of that women as it is not natural. So, I cant decide about it this moment (GD_2 P_{10}).

Likewise, in the group interactions as well, some students weighed economic and health concerns when deliberating on whether being involved in a surrogacy arrangement is a good deal for poor women. For instance, in the following group discussion, a student deliberated on whether the money that the surrogate mother earns would suffice to sustain her:

EXTRACT 7

GD_2 P_9 :	It is allowed for only 3 times and 50000 Rs ... 3 times (50000) ... for a lady it is 1.50 lakh, how can she survive (a) full life with 1.5 Lakh?
Facilitator 1 :	(So) you feel that the amount is not so much?
Facilitator 2 :	No … no let us clarify … 50000 is the lower limit
Facilitator 1 :	Yeah ... its the lower limit
Facilitator 1 :	Upper limit could be a few Lakhs
Facilitator 1 :	So about 5 lakhs ...15 lakhs
GD_2 P_9 :	Maximum amount would be 15-16 lakhs ... it depends upon her … if she can withstand it the … the whole life then it is good...but if the money she is getting is not enough ... if it is just 50,000...

In a group discussion involving two girls and a boy, similar considerations were raised:

EXTRACT 8

$GD_1 P_1$: It's useful for infertile couples ... but the case still remains that the surrogate mother *after* having a baby it would be tough for her survival.. it's like...only three times in a life...

$GD_1 P_2$: ill effect of health ... 3 times … (to $GD_1 P_3$)

$GD_1 P_1$: Nine lakhs ... twenty seven lakhs maximum a woman can earn in her life time… twenty seven lakhs ... who spends her life on twenty seven lakhs? I think it's not a good source of income.

It is interesting that when conducting a cost-benefit analysis of the financial gains vis-à-vis health risks that the technology may pose to the surrogate mothers, students hardly focused on what an *acceptable level of health risk* would be or raised questions that would lead them to answering this. To be sure, students asked whether there would be health risks at all, but did not raise further queries on what the nature of these risks are, or what would be acceptable levels of risk.

b. Concerns related to Access

The bioethical principle of justice is concerned with issues such as universal access to health care, who should bear the costs of medical treatment and so on. One student from the interview and two students who attended the group discussions raised concerns regarding universality of access; expressing discomfort that only the rich, who can pay for these services utilize the technology:

EXTRACT 9

> It is a good solution for rich infertile couple because only some can afford commercial surrogacy. But poor infertile couples cannot afford this thing. ($GD_2 P_{11}$)

In a group discussion involving two girls and a boy, the girls raised the issue of whether the technology should be made affordable to all through the public health care system. The boy, however, dismissed it saying that the poor cannot take care of their children anyway, and hence, it is futile to make the technology accessible to all:

EXTRACT 10

$GD_1 P_2$: They should provide this (IVF) for the poor..

$GD_1 P_1$: No

$GD_1 P_3$ and $GD_1 P_1$ interrupt.

$GD_1 P_1$: Wait..stop!.. if they are poor, how will they satisfy the needs of a young one..how do you think? they are poor..they cannot (ought not to) have a kid..come on..what will they do?

$GD_1 P_3$: For this, I think even in government hospitals should have this (these) fertility clinics.

$GD_1 P_2$: Why will they provide? (to $GD_1 P_3$)

$GD_1 P_3$: To fulfill the need of the infertile poor parents...

$GD_1 P_1$: Joseph Sir (pseudonym for a teacher in their school)... Joseph Sir has taught us...entertainment..for poor people, it is entertainment to have kids... Joseph Sir ...((in a tongue in cheek manner, looks at $GD_1 P_3$ and smirks)

In a common group discussion with the facilitator, another student raised a similar point:

EXTRACT 11

$GD_1 P_5$: [...] I have heard that in adoption, mostly there are children who are just left away by the parents just because they can't pay the money and can't raise them ... if we afford IVF (if IVF is made affordable to all) what is the use of the poor people ... like … the poor people use IVF but they can't raise it (their children) and they give them to the orphanage ... then whats the use of it?

Facilitator : What's the use of poor people accessing IVF ... anyway they don't take care of their own children... ? (clarifying $GD_1 P_5$'s response)

$GD_1 P_5$: They cant raise them much...

$GD_1 P_1$: They can't take care of themselves … so how are they expected to take care of little young ones?

c. Concerns regarding autonomy and choice

One principle of bioethics that is important to employ when evaluating any medical technology is autonomy on the part of different users of the technology, to make informed decisions regarding whether to use it or not. When it comes to the question of an “autonomous

decision" in the case of a surrogate mother, it needs to be kept in mind that a lot of decisions that the poor are compelled to make with regard to their lives are passed off as free and informed choices in the current capitalist regime, when very often, these choices are excercised because the larger socio-economic structure fails them. Critical science education ought to enable students to see what lies beneath these so-called "choices" that are often made under the compulsion of poverty.

In the second part of the interview, students were specifically probed on what their opinions were on the position that views inherent injustice in the fact that it is poverty that compels these women to choose surrogacy (at the cost of risks to their bodies), whereas the rich never resort to surrogacy to earn a livelihood. It is not very clear if all the students really understood this position from the way it was presented in the probe and the interview. Hence, I have exercised caution when interpreting the results from this part of the interview, given that the argument is complex and many of the students may have encountered it for the first time. However, some of the responses are still worth mentioning as they afford insights into students understanding of the nature of poverty and the choices people make within that context.

Some students felt that it is a straightforward "choice" that the surrogate mother excercises, when she makes use of these technologies:

EXTRACT 12

I : You know many people think that surrogacy should not be encouraged because it encourages only poor women to come forward to earn money by using their bodies for this purpose … so again you know it is noticed that its only the poor women ...not the rich women who are opting for it, the money is one lakh per pregnancy […] people say that there's something unfair that only poor women are coming forward for it and not the rich. So what do you feel about this issue?

P_1 : See it's a person's choice whether she wants to be a surrogate mother or something, if a rich person doesn't want to be a surrogate mother, its her view ... its not her child … she had reproductive organs to bear her child, not somebody's else child ... and if a person is doing it it's for her own good will ... if a person is rich why will she need more money … she already has enough money. So ... we cannot say that rich guys are doing a wrong thing or not doing a just thing by taking

> advantage of the poor people. Actually they are not taking advantage of poor people. The poor people are using infertile people and they are taking money from infertile couples to just bear a child because the larger socio-economic structure fails them (emphasis added) […] Even if a person is poor and she produces more children, who again become poor and they have more children.. so the cycle goes on and we just produce more people who are unemployed and are poor, but if we allow such a thing (IVF), she might become rich and help the family.

In the above response, we see the student totally inverting the question and placing the onus on the poor to break out of the "vicious cycle" of poverty.

Some students seemed more receptive of the concern that it might be their abysmal economic conditions that lead the poor to make risky choices, as evident in this exchange:

EXTRACT 13

I :	…so a similar objection that was raised for kidney trading is also raised for this...that a rich women will not opt for surrogacy and poor woman
P_{11} :	In need of money..
I :	...on account of her social condition... her poverty... she is actually lured to make these kinds of choices, where she has to use her body... you know... things of that kind. So do you agree with this problem or... do you feel that...
P_{11} :	Actually that's a wrong thing because the poor people, obviously they need money so they come forward and they use their bodies to give birth to the young one. It's not correct but on their part they need money so they are doing that. But if we think the other way it's not good, even rich people … they don't need money so they obviously don't come forward so they are misusing the... conditions of poor people, because they (the poor) are in such a condition that they can do anything for earning money. That's a wrong thing to do...
I :	So then what about this whole thing of having your own child... and looking for means to do that?
P_{11} :	They could adopt children, there are children...which (who) at a very small age are being dumped by their parents. So they could go for an adoption..

Another student spontaneously raised the question of autonomy in her interview:

EXTRACT 14

> Yes, if it's their (surrogate mother's) decision..whatever..it is for money then it's OK but if they are doing under some pressure because they are very poor and they don't have no source of money or something like that...so I don't think that its right way, doing it just for money..because it will affect her body. (P_5)

Here she makes a nuanced point that though the surrogate mothers' decision has to be autonomous, it cannot be made under the compulsion of poverty, as her health might get affected.

d. Concerns related to the nature of family

Worldviews represent a collection of conscious beliefs about how social or physical reality is organized or how it ought to be (Rohan, 2000). Apropos of how we understand the concept of family, a worldview that would support biological parentage would believe in the sanctity of blood relations and maintaining the bloodline whereas one that upholds a social family may question the primacy of blood relations in defining a family, viewing practices like adoption as being equally, if not more acceptable. These views may stem from underlying worldviews that have basis in caste, patriarchy and religion. While in most cases there were no references to these aspects, in some responses there were explicit references to religious conceptions and patriarchal notions. In addition, some students raised concerns regarding the morality of surrogacy as a practice that may stem from patriarchal notions of the chastity associated with womanhood. These concerns have been elaborated below.

Students adopted differing standpoints on the necessity for a genetic/biological family (ensured through reproduction). Four interviewees and one student who participated in the group discussions, explicitly considered the social family through adoption as an alternative option for infertile parents. Out of these, two students suggested adoption after giving thought to the health risks posed by the technology to the surrogate mother:

EXTRACT 15

> Yes, it is a good solution for people when they cannot have children biologically because having a child is a dream of parents or people. But also I cant say because what about the health of the surrogate mother. As I have learned after giving birth

> to child the surrogate mother should take rest for at least 4 years. Instead of IVF. The parents can also adopt children who are orphan. ($GD_2 P_4$)

Responses such as the above did not question the necessity for a biological family *per se*, while the other two responses did. One example of the latter is:

EXTRACT 16

> It's just their own family. You can treat some person like your family. It needn't be your own blood and that, its the treatment. So according to me its not a good idea. (P_{19})

Among the interviewees, three students stressed that having a child with one's own genetic traits is desirable. For example:

EXTRACT 17

> ...Yes, because it should not be so that if due to your own personal problems you cant have your child, you have such kind of technology to develop your own child with you own genetics with your own traits, so I think there is no harm to do so. (P_{10})

Most other students were silent on the issue of whether they really viewed biological family as valuable in itself, while some students (one among the interviewees and three in the group discussions) adopted a position that seemed to suggest that the parents have no choice but to succumb to societal pressures to have children:

EXTRACT 18

> For the couple its (IVF) a very good thing..because if they don't have children the whole family is irritating...(P_{17})

These students may not be pro or anti biological family, but may believe that it is difficult to resist dominant societal norms which reinforce notions of caste and genetic purity.

In the whole group discussions with the facilitator(s), there were exchanges on whether having one's own biological child is necessary or not. In the following conversation, for instance, that occurs between the facilitator and a few students, this point was brought up:

EXTRACT 19

Facilitator :	So do you think this attitude of the society ... [...] this is a good attitude that ... [...] the child should have the genes of the parent … do you find that a good ... attitude a good value ... for a society to have?
GD_2P_9 :	No
GD_2P_3 :	Ma'am... society should learn to accept (the adopted child)
GD_2P_1 :	Society almost every time it (society) goes for negative thinking...it thinks
GD_2P_9 :	Not even the genes, the environment in which the child is brought up...is..what affects it (his) nature when he grows up...if he grows up in a good environment then what do we have to do with the genes...even if he is adopted he has very nice parents..very affectionate parents and who bring him up in a proper way...why does it affect the society in any way?
Facilitator :	You were saying....that you are pro- IVF...why do you feel that way ? (to GD_2P_8)
GD_2P_8 :	Because the genes are of the parents only...so the parents can get their offspring but in...but in (using) a different method...So I feel IVF is much better...even when it comes to adoption we are actually helping a child get a home … but the society is still not accepting even this ... so this method IVF is a bit acceptable by Indian society or by a couple … *at least their genes are same* (emphasis added) ... we are only hiring the womb of a lady ... so its better
Facilitator :	So the thing is, do you feel the societal attitudes should change or should they take (use) technologies like this which would enhance acceptability?
GD_2P_3 :	Ma'am … both are positive but society should take an initiative to accept things, and at the same time, improve technology

Above, we have students adopting different positions on the desirability of ensuring genetic lineage through the use of IVF. While GD_2P_9 puts forth an interesting argument that the environment has an important role to play in constituting the “nature' of the child, GD_2P_8 rebuts saying that even though adoption gets a child a home, it is desirable that the child inherits the genes of his/her parents, as it is better to appease societal norms.

In a group discussion involving four boys, one student believed that adoption might be a

better alternative:

EXTRACT 20

$GD_2 P_4$ reads out his answer in the worksheet.

$GD_2 P_4$: Yes, it (IVF) is a good solution for people when they cannot have children biologically because having a child is a dream of parents or people. But also I can't say because what about the health of the surrogate mother. As I have learned after giving birth to child the surrogate mother should take rest for at least 4 years. Instead of IVF. The parents can also adopt children who are orphan.

$GD_2 P_3$: Good point to make.

$GD_2 P_2$: This is a controversial point...what if there are people who want their own genetic child?

$GD_2 P_3$: For self-centered people!

$GD_2 P_2$: *S*hut up!..do this seriously...

What is also perhaps worth noticing in the above conversation is how one of the boys who discusses possibilities of adoption as an alternative is silenced by another member of the group. One of the preconditions for effective dialogue is the willingness to listen and respect opponents views in a discussion. As Levinson (2007) points out, it is important to instill communicative virtues in students when debating socioscientific issues. In the above exchange, we witness a case where one student silences the other without engaging in a respectful discussion.

In yet another group discussion involving two girls and one boy, a boy raised the possibility of adoption as an alternative to IVF:

EXTRACT 21

$GD_1 P_1$: But you can adopt a 6 or 7 year old child..then u don't have to have injections or stuff like that..

$GD_1 P_3$: It depends on what the family wants..an adopted child or their own..

Thus, we find students taking varied positions on the issue of the desirability of a biological family. A minority of the students held rigid views on the issue – upholding the need to ensure genetic lineage or alternatively, held the converse viewpoint that stresses on reimagining the

family as a social unit (P_{19}'s response). There were a few who believed that procreative choice needs to be granted to the parents, without being clear on their own positions regarding the matter.

That said, in the aforementioned cases, the reasons as to why students adopted a stance that would support a family based on biological or social relations are not clear. There were, however, a few cases where students argued on the basis of religious beliefs. Three participants invoked religion in their arguments regarding the technology. One male student made an ethical argument against adopting IVF because his religion, Islam postulates that one should be satisfied with what is ordained by god:

EXTRACT 22

> ...Naturally what God has given them they should do it or else leave it... (P_{16})

Ahmad (2003) refers to a verse in the holy *Quran* that concerns infertility,

> To God belongs the dominion of the heavens and the earth; He creates what He wills; He bestows male or female, according to his will; or He bestows both males and females and He leaves barren whom He will; for He is full of knowledge and power. (Surah 42: 49-50)

The student's responses seems to have resonances with lines from this verse, albeit there being no way to tell whether he directly drew from it. It must be noted that Islam, according to some scholars, is not against the use of assisted reproduction as it confers special status to blood relations. However, it would forbid surrogacy as a third person, apart from the biological parents would be involved (Ahmad, 2003, Fadel, 2002) because according to Fadel (2002), Islam considers the person who gives birth, the mother, primary. Surrogacy would thereby complicate the situation.

A female, Muslim student who participated in the group discussion mentioned that Islam would prohibit surrogacy. She believed that IVF should be an option that infertile parents ought to consider:

EXTRACT 23

> So some people who really are following Islam..they may not come into this. They will not follow these procedures, they would go to some other lady (meaning re-marriage). Because the blood of the baby comes from that...The nutrition is derived from that mother. So we don't know who is she, how is she? she comes from which religion? which caste? So they might have that kind of issues and even if we are Hindu typical society, they tell that if she cannot become a mother we will marry some other lady and we will make her our in-law. ($GD_2\ P_8$)

This student was pro-surrogacy because she believed that it would prevent Muslim men from abandoning their wives and re-marrying if they are unable to conceive a child.

In yet another group discussion, a male student invoked Hindu astrology when carrying out an evaluation of adoption vis-à-vis the use of assisted reproductive technologies:

EXTRACT 24

$GD_1\ P_4$:	I think adoption also in some ways is not good. Because if a couple adopts a girl child, when she is in the age of ... of the age of marrying, if the boy who is going to marry know that she is adopted girl...like in India mostly for marriage they see astrology and all..so..they think..they will not be knowing of the astrology ... who she is ... means ... out of caste ... so they wont marry her
Facilitator :	You mean girl children won't be adopted..
$GD_1\ P_4$:	Means if they are adopted ...
Facilitator :	You mean they won't get married?
$GD_1\ P_4$:	It will be a problem for marriage
Facilitator :	So for those reasons you think that its better for people to go in for IVF. OK ... interesting.
$GD_1\ P_1$:	In our primitive society it is considered as "bad blood". She cannot be considered in our society (she would not be accepted in our society)
$GD_1\ P_4$:	They won't be knowing whose child she is and what type of family she comes from ... so they won't get married to her (get her married) … in the age of her marriage (he reiterates).

In the above exchange, we have a student pointing out that if a girl is adopted, it might

become difficult to get her marriage arranged when she comes of age, because astrology would require that the details of her birth be known (date, time etc.). He also mentions that not knowing her caste would be a problem. Another student however counters him, questioning "primitive" societal attitudes that call for preserving the sanctity of blood lineages on the basis of caste and patriarchy.

e. Concerns regarding social acceptability of the surrogate mother

Some students raised concerns regarding the impact of the technology on the surrogate mother and her social relations. Among the students who were interviewed, four raised concerns regarding society's acceptance of the surrogate mother. They were concerned about her being perceived as someone with inferior character:

EXTRACT 25

> ...if its their choice its OK.....I don't think that anyone would like to marry to such a girl, I don't think most of the families... of the surrogate mother...won't be ready. We have a cultured society... (P_5)

Another student, P_3, referred to a case that she read in a newspaper regarding a married woman who opted to become a surrogate mother and did not inform her family:

EXTRACT 26

P_3 :	...It should not be like just for money she is not even telling her family ... because the family also people will think ... how can she carry someone else's child..
Interviewer :	So you feel that she should be getting her family's approval?
P_3 :	Yeah ... approval should be there

In yet another conversation between a boy and two girls, the boy (GD_1 P_1) raised concerns regarding how engaging in surrogacy might affect the social acceptability of surrogate mother:

EXTRACT 27

GD_1 P_1 :	How do you think that the society will accept it. Just think about the

surrogate mother, the first thing our primitive society think for surrogate mothers (interrupted by GD_1 P_2)

GD_1 P_2: It has many does and dont's ...

GD_1 P_1: (continues) they are having others' kids they cannot be with us...If I was the owner of society ...when a surrogate mother comes in society the first thing people will tell about or gossip about her is that she is not a good woman...she is having others' kids ... she cannot stay with us and its like ...hell about surrogate mother.

GD_1 P_3: The other side of the topic ...first side is that its useful for them...

In the above conversation, GD_1 P_3 and GD_1 P_1 appear to disagree over whether social acceptability of the surrogate mother's profession is really a concern. While GD_1 P_1 appears to think so, GD_1 P_3 ignores his response.

f. Economic Concerns

Responses invoking economic concerns discussed the role of the technology in economic development of the individuals involved or the nation at large, or the nature of poverty. Three students in the interview, and a student who participated in one of the group discussions harbored the naïve belief that the technology may actually alleviate poverty of poor surrogate mothers.

See, for instance, the following excerpt from an interview:

EXTRACT 28

Interviewer : Many people say that there is something wrong with this aspect that only poor women and you know its basically only poor women, who come forward ... this technology fulfills someone's need for money. Do you find this an issue?

P_2: I guess its not an issue because if the poor is developing … and I guess they should be encouraged for that and any how it is not costing them anything, anyhow the society....they reject them....even if they become surrogate mother I don't think there is a problem. Because the whole family will be knowing that she is a surrogate mother and she is earning.....the whole family will be graduating to the middle class..and they have said three times (three surrogate pregnancies are permitted by the government) … so I don't think there is a problem.

Two students believed that the technology would bring about overall development of the

nation. As one student pointed out, poor women getting employment would lead to the development of the nation:

EXTRACT 29

> Now, because surrogate women are paid, when there's a good source of income, good livelihood isn't far. This may be a long shot but women who dwell in slums suddenly get a livelihood, then development of the nation isn't far. ($GD_2 P_3$)

The other student also raised a similar perspective:

EXTRACT 30

> ...This technology is not only useful to the parents who cannot have children biologically but also to the poor and as well as the country. As due to this technology which cost very less in India, even more foreign people visit India for this thing. So even foreign investment in medical field i.e. for medicines and for treatment its increasing due to this technology. ($GD_1 P_3$)

What the students do not recognize is that not only does the technology not bring significant prosperity to the surrogate mothers, it actually leverages the unequal social context to sustain itself and reap profits to its providers. As Longino (2015) notes in her commentary on assisted reproductive technologies in India:

> Only a small fraction of Indian women have access to these technologies to assist in their reproductive endeavors. But the technologies are spreading as poor Indian women essentially rent their wombs, their bodies, to assist in the reproductive endeavors of more affluent women, often from abroad. What are the values that can see this as any kind of economic empowerment or development? The point is not that women are coerced, rather the point is to question the system of values that cab welcome the net gain to the GDP that this practice might provide without thinking about the safety or health of the women whose bodies are used to bring the foetus of others to term. (p. XII)

The above discussion calls to mind that some students also raised concerns regarding the nature of poverty in their responses, indicating that they were confused about how to understand it. For instance, in a group discussion, a boy asked other members of his group the following:

EXTRACT 31

> Eh ...just a minute … how are you … just recognizing these people ... like common man, rich man? (GD_1 P_1)

Here, the student appeared perplexed about how to understand the basis by which categorization of people into poor or rich happens. Similarly, a student, in an interview, when talking about poor women engaging in surrogacy pointed out:

EXTRACT 32

> See the term *poor women* (emphasis added)... I think once... three times (surrogacy) in her whole life? once you have done for the first time, so you get a lakh rupees, so its enough..you are no more a poor woman. (P_{10})

One female student viewed the technology as helping surrogate mothers to become independent as they are often exploited by their husbands:

EXTRACT 33

> ... the surrogate mother will get the satisfaction out of getting 3 lakh rupees...that is a pretty good amount..in poor families women are not considered as equal to men...these women can open a bank account and deposit it there. (P_{17})

4.6.2 Epistemic concerns

Epistemic concerns raised by the students included those that invoked disciplinary knowledge (textbook-based and otherwise) or those that sought evidence, particularly related to health risks the procedure poses to the surrogate mother and other stakeholders.

a. Concerns that invoked disciplinary knowledge

Students referred to very little disciplinary knowledge in their considerations. One dominant concern was whether the child born through the IVF procedure would be deprived of “mother's milk”:

EXTRACT 34

> ... it may be harmful for the child not much but little because it might not get

> mother's milk which provides basic immunity to the child, which in future would result in poor health. ($GD_2 P_9$)

Another student attempted to employ disciplinary knowledge in an erroneous manner when discussing how to optimize the technology in a manner that would ensure that a male child is born. In a group discussion with four other students, he pointed out that it is important for the surrogate mother to be healthy for the child to be born as a male:

EXTRACT 35

> ...the surrogate mother has to be healthy ... in that condition if she is not healthy *matlab* (means) ... if she is healthy and good enough then the father will act more (father's genes will express more) ... and if it is a boy ... that is the XY chromosome … then there is a more chances of having genetically like the father ... more than the mother. ($GD_2 P_2$)

What is interesting in the aforementioned statement is not just the fact that the science is wrong, but how science is being invoked to discuss how to optimize the technology to serve value-laden aims. In this case, it is the patriarchal end of having a male child or a child with paternal traits.

In yet another interesting case of discussing ways to optimize technology, another student pointed out that the technology could be modified in such a manner that it does not disturb the menstrual cycle:

EXTRACT 36

Interviewer :	Can you think of any other issues with a procedure like this ... I mean...
P_{15} :	Another thing will be that how it affects the surrogate mother … means ... It would be better if the time of implantation of the zygote would be matched with the menstruation cycle of the surrogate mother...
Interviewer :	that is not possible because (naturally) fertilization happens inside the body. A certain set of events happen naturally in the body. But in the case of the surrogate mother ... see the problem is that the fertilization is happening outside. Its not like artificial insemination. You know what is artificial insemination...
P_{15} :	Yeah
Interviewer :	So in this case, the sperm is directly injected and the changes happen

naturally … in this case (IVF), you have to make her body artificially ready for the pregnancy.

P_{15}: But if it is possible to simulate these circumstances … If it is possible that the female has produced the ovum and at the rough time when it is ready to fertilization then that time the zygote is implanted into the uterus of the female, removing the ovum...then in such a case it would be a better alternative than the hormonal treatments … because then there would be less amount of side effects.

Interviewer : But unfortunately that is not there.

P_{15}: In that case there should be specific time ... means ... it should be not be such that once a female has to be a surrogate mother and immediately after delivering the child she will be allowed to work again. There should be certain lag period, it would be feasible to recover from the extra hormones that she has been put.

Above, we witness the student trying to find out whether it is possible to modify the technology in such a manner that it does not disrupt the system. He assumes that interfering with the system will cause harm to the surrogate mothers' body. Very interestingly, his understanding resonates with certain feminist critiques of reproductive technology, as in the excerpt below:

> We believe that modern medicine and traditional live knowledge can together arrive at methods that would help every woman identify these fertile days for herself. The biological knowledge that has been evolved so far about the (menstrual) cycle has to be used to understand and live in synchrony with the menstrual cycle. It cannot and should not be used to achieve control over the cycle. (Manorama & Shah, 1996, p.38)

Further, Manorama & Shah point out that contraceptive technologies aim reductively at preventing the event of fertilization, ignoring the systemic dimensions of the menstrual cycle. This in turn causes hormonal imbalances and severe health risks to women who use these technologies. Thus, in the aforementioned extracts, we have instances of students suggesting modification of the technology to suit value-laden ends. In one case, it is with the end of achieving the traits of the father, in the second case, it is to ensure that minimum harm befalls the surrogate mother as hormonal imbalances could cause side effects.

Besides the aforementioned case, in another whole classroom discussion (see extract 19 above), we also have a girl (GD_2P_9) making a point against reductionism when, in an argument on whether there is really a need to have genetic families, she points out that the "nature" of the child is not determined by the genes but by the environment. This was not discussed further, but it exemplifies an instance where a student brings in knowledge which was not from the textbook.

b. Concerns related to evidence

During the course of the interview, some students raised questions regarding the kind of health risks the procedure would pose to the surrogate mother (9/20). These students were further probed regarding what they considered would be authentic sources of evidence. Responses suggested talking to fertility doctors, surrogate mothers or searching the Internet. When probed regarding how to determine reliability of these sources of evidence, the students seemed unsure about how to go about it. This was investigated more thoroughly and in a structured manner in the group discussions. This is further elaborated in chapter 5.

4.6.3 Standpoints adopted by students

Trends in the interview data suggest that some students espoused standpoints based on the perspective of different users of the technology or what I term people-based standpoints while some others assumed principle-based standpoints on the issue. With the rest, it was not clear whether there was any motivating interest position, or principle which moved them to take a position on the issue.

a. People-based standpoints

Students assumed various standpoints with regard to the stakeholders involved in the issue. Seven students adopted the interest position of the surrogate mother, three adopted the interest positions of the biological parents and one student took on the interest position of the baby to be born.

The following excerpt from an interview is illustrative of the participant adopting an interest position that favors the surrogate mother :

EXTRACT 37

Interviewer : So my question is what is your opinion on something like this... commercial surrogacy. Do you feel that its good that people who are not able to have children naturally are able to go for this?

P_5 : For the people who are not able to have children for them its obviously good so that they will be able to get the child. But the people who agree.. themselves.. you know...its their opinion..if they are ready...its fine for them...

Interviewer : By people who agree, you mean surrogate mothers.

P_5 : Yes, if its their decision..whatever..it is for money then its OK but if they are doing under some pressure because they are very poor and they don't have no source of money or something like that...so I don't think that its right way, doing it just for money..because it will affect her body and taking into consideration the society also..its not good...

Some students (three), seemed more concerned about whether the surrogate mother would disagree to part with the child or have some inherent "problems" (with their bodies) than whether the technology would pose risks to her body. I read this as a position that is sympathetic to the needs of the biological parents. One student, for example, was concerned that the surrogate mother would not reveal her "problems" if she was going to be paid for carrying a baby:

EXTRACT 38

P_{14} : ...if there aren't problems with the surrogate mother like… people wont tell … if they are getting money for such a stuff they won't tell problems that they have.

Interviewer : What problems?

P_{14} : Problems that would affect the child. Like they say that if the mother has a particular disease when she is pregnant

Another student mentioned that the surrogate mother may not give up the child and go back on the agreement:

EXTRACT 39

... Some women agree to become a surrogate mother but later on the child is growing inside them so they deny to give the child away and say its my own kid then they cancel the agreement something they deny that they will deny ... don't

want money. But again in future the child grows they say that..no you are not my child... (P_2)

Responses such as the above reflect a certain positioning that is suspicious of the surrogate mother. Some exchanges in the group discussions also indicate clashes between interest positions. In one such exchange between three girls where they discussed the state of the surrogate mother's health, one girl was unable to understand the other interlocutors' point of view.

EXTRACT 40

$GD_2\,P_8$ reads out her response:

$GD_2\,P_8$: "..as she is doing a strenuous job going from house to house..her body might be very weak"

$GD_2\,P_9$: Actually I think she will be very strong.

$GD_2\,P_9$: I don't agree with your one point...if people do work... that means that they are very healthy

$GD_2\,P_{10}$: No...Its not like that… if she is working in 5 houses... if she is working …obviously her body will be very weak

GD_2P_9: Look..people used to say this in the olden times (that if you do work, you will be healthy)..even now people say it..OK? [referring to an old saying]

$GD_2\,P_8$: Even now people say ... do your own house work… your *own* housework and you will be healthy..but so much work this lady does..

$GD_2\,P_{10}$: No ... but she does the housework of five houses ... and so well!

$GD_2\,P_{10}$: You do it! (and lets see how healthy you will be)

$GD_2\,P_8$: You do it and tell us!

$GD_2\,P_9$: This is not a matter of a day … she must be doing it for such a long time!

$GD_2\,P_8$: Such a long time..that is what..such a long time..she will need to bend and do the work...there will be problem in her knees

$GD_2\,P_{10}$: Not all the time everyone is healthy

$GD_2\,P_{10}$ talks about her father whose work demands a lot of standing and the ensuing health difficulties that he faces.

$GD_2\,P_{10}$: It will be a problem for her in the long term

$GD_2\,P_9$: She is not 40 or 50...

$GD_2\,P_8$:	She is 32!
$GD_2\,P_9$:	She is 32 … so she can go ahead with that idea. Tell me whose *bai* (Household help) has fallen ill? Have you ever heard of *bais* falling ill?
$GD_2\,P_8$:	(Indignantly)Yeah!
$GD_2\,P_{10}$:	Always ... My household help is always sick
$GD_2\,P_{10}$:	It depends on the..
$GD_2\,P_9$:	No...
$GD_2\,P_8$:	Different (kinds of) bodies actually
$GD_2\,P_9$:	No I don't agree with you. No.
$GD_2\,P_{10}$:	Arre! if she keeps working her joints will get affected
$GD_2\,P_9$:	(inaudible)
$GD_2\,P_8$:	I will write this as a counterpoint
$GD_2\,P_9$:	... because see..if you run for several days..and in the long run, you get immune
$GD_2\,P_8$:	I know that in the long run there will be problems (for her)
$GD_2\,P_9$:	But when in the long run?..at age 40-50?
$GD_2\,P_8$:	Its not necessary ($GD_2\,P_{10}$ also chimes in) when she is 25, she can get some problem... 30-32-35...
$GD_2\,P_{10}$:	Late 30's
$GD_2\,P_9$:	Late 30's...now she is perfectly fine
$GD_2\,P_9$:	No, I don't agree
$GD_2\,P_8$:	On what basis you don't agree? (some mumbling)
$GD_2\,P_9$:	No I don't agree
$GD_2\,P_{10}$:	You have no counterpoint!

In the above discussion, $GD_2\,P_8$ and $GD_2\,P_{10}$ adopt the interest position of the surrogate mother, while $GD_2\,P_9$ is unable to do so. $GD_2\,P_9$ almost appears to treat her as another species, on whom a completely different set of rules apply, as evident in the kind of references she makes to the surrogate mothers' body and its immunity to any kind of ailments. There is an othering that is taking place, of the surrogate mother. It also needs to be noted that in the aforementioned exchange, we find the students engaging in a friendly debate. The discussion trails off with $GD_2\,P_{10}$ pointing out that $GD_2\,P_9$ has no counterpoint, and there is *no basis* for her to disagree. This is in stark contrast to the exchange in above, where one of the boys,

through sheer exercise of authority, shuts another boy up without engaging him in any debate.

In the whole class discussion too, we observe a similar exchange on whether surrogacy is an appropriate option for poor women who are in need of money, where students argued from seemingly different interest positions:

EXTRACT 41

Facilitator :	OK...so the next question is... Do you think that being a surrogate mother is a good source of employment for poor women? So basically I mean a lot of poor women come forward to become surrogate mothers. Do you think this is a good way of getting money and so the question is why or why not and please elaborate...What does this group feel? Do you feel this is a good way of making...
$GD_2 P_{12}$:	This is a good source of employment but..as it let them to earn about 50,000 to lakhs...50000 to lakhs but for poor women may be...poor women opt for it but..because of the hardship they can face in society due to that poorness, they can have undergone many diseases and all so, and if this may lead to their weakness, and if they go for surrogacy and carry a baby for 9 months it may all lead to their own weakness. So for 9 months they will be paid but after 9 months what will they do...if they become more weak..so it may be difficult for them to live in this society.
Facilitator :	OK... so...
$GD_2 P_2$:	No..but they can earn...
$GD_2 P_2$:	IVF do such kind of tests before..
Facilitator :	They do some basic tests like...you know sexually transmitted diseases ...those kind of things are screened
$GD_2 P_2$:	They have information on how many times she has given birth to a child...whether she has had any abortions or something like that.. like that
$GD_2 P_{12}$:	Ma'am but the question is also is it good source of employment for poor women..thats why poor women are almost 50% less then are healthy...many are very unhealthy..so thats why....
Facilitator :	Right.. so what do you think about this point?
$GD_2 P_2$:	But IVF...
[..some discussion that is irrelevant]	
Facilitator 1 :	I'll just (complete)..what does everyone think about this?..that most poor women are quite weak...
$GD_2 P_3$:	Yes..yes

$GD_2\,P_9$: Ma'am..doctors take sufficient care that surrogate mother is completely healthy to carry a child..why would a parent go to a mother who is not well...So mostly they only opt for those mothers who are well...healthy..and..

Facilitator 1 : The point that she is making is....see that poor women do come from a certain background...OK so they don't have good access to nutrition

$GD_2\,P_1$: If the most women are also....

Facilitator 1 : So how healthy are they?

$GD_2\,P_9$: If the poor woman is not coming from a good background then she is not healthy enough and she has some disease,then I guess the doctor will refuse her directly that she cannot...fit to carry a child.

Here, we have a case where a student, $GD_2\,P_{12}$, makes a point that a surrogate mothers' health is already compromised on account of malnutrition and that she might not withstand the IVF procedure because of these reasons. $GD_2\,P_2$ and $GD_2\,P_9$, however, fail to see her point. They interpret it to mean that weak surrogate mothers will be chosen, who would be too weak to carry on the pregnancy, and hasten to point out that such women will be screened out.

b. ***Principle-based standpoints***

Another group of students (three) appealed to certain basic ethical principles when reasoning about the issue. While one student's position appeared to be motivated by his religious beliefs, what may have motivated the other two students' positions is not clear. For example, the student below adopted a pro-adoption stand point:

EXTRACT 42

P_{19} : Actually, I don't think its OK. because people who are not capable of producing a child... they can just adopt the child. I have heard that if a woman is getting pregnant its her mental satisfaction of pregnancy. If a mother ... the biological mother she is not going to have such feelings, in her point of view it its just another baby, just she is a biological mother, its not going to harm her, so its equivalent to adopting the child...

Interviewer : OK..means you are right, but the thing is there are people who feel that in spite of...see some people do not want to go for adoption. They say that we want our own genes, we want a child who looks like us. So for such people do you feel that such options are...

P_{19}: Such people....determined people...according to me I don't think that such option is useful for such people looking like us. Its just their own family. *You can treat some person like your family. It needn't be your own blood and that, its the treatmen*t. So according to me, it's not a good idea.

P_{19} later raised considerations regarding health risks and so on, but what seemed to have troubled him fundamentally was the premise on which the technology was built-- the genetic family.

Another participant GD_1 P_1 adopted a position which opposed commodification of the surrogate mothers' body. In a group discussion, which involved him and two other girls, they deliberated on whether surrogacy is a good source of employment for surrogate mothers:

EXTRACT 43

$GD_1 P_1$: Yes its a good source of employment *but* its trading a women for money, like you are selling your body for nine months...like..how do you feel about that

$GD_1 P_3$: But she has to earn money...any how...

At a later point in their discussion, he continues to argue this out:

$GD_1 P_2$: But this (surrogate) mother is provided with a lot of care during that nine months.

$GD_1 P_3$: (in agreement with $GD_1 P_2$) hmm ... hmm

$GD_1 P_1$: Its like.. its like I am buying some fish from a pet shop.. and I am owning that fish.. it means...it means that I am buying the woman..its like illegal stuff...seriously

$GD_1 P_2$: But when that the couples are not having the..They should find some or the other way to get a child.

$GD_1 P_1$: IVF is a better technology but still..

$GD_1 P_2$: But when the surrogate mother is..this one (taps on the desk with her pen) is not good..

$GD_1 P_1$: For just having their *own* baby, its like paying to a mother.. there are certain adoption centers, there are children just lying down there..there is no parents..

$GD_1 P_2$: They can adopt babies.. adopt babies instead of this...(interrupted by the boy)

$GD_1 P_1$: Yes, they can adopt babies instead of surrogate mothers and stuff like

that.

$GD_1 P_3$: (little defensively) Then there is no use of this technology… means... there is no surrogate mother... then no use of this IVF. Both the parents are infertile.

Above, we find that $GD_1 P_1$ is able to convince one of the other participants, $GD_1 P_2$. However, $GD_1 P_3$ is not convinced.

Another student assumed a standpoint motivated by his religious beliefs:

EXTRACT 44

> ...but according to me... means now... in my background... in my this... now my aunt is there... They are not having children....my father was telling that the problem may be with uncle...his sperm count is low. But in our this..Islam they tell that.. that people should not do all these things. Naturally what God has given them they should do it or else leave it...means this is not a harmful thing if we do not have children. *This is only for our satisfaction* (emphasis added). So means... I feel that it should be... means if the parents think that they should have a child, they should have a normal parenthood then they should go for this technique. Since they may have a child. But is this 100% successful? (P_{16})

In all of the aforementioned cases, students questioned the need for IVF on the basis of some principles. In the first case, the student believed that the genetic family is unnecessary and that it is always possible to treat someone as one's family. In the second case, the student opposed gestational surrogacy, as he believed that it effectively commodifies the body while in the third case, the student believed that his religion, Islam, would prohibit this practice. Though some other students also raised these issues, what stands out in the above responses is that the technology challenging these dearly held principles seem to be the primary reason which made them uncomfortable. For other students, these concerns did not seem primary, and they would bring these up only later, as they built up their arguments for or against the technology. Since responses that reflect a principle based standpoint are few, we may need further studies to really confirm whether this is indeed a significantly different style of reasoning.

4.7. Discussion

4.7.1 Students' concerns

Students raised multiple social and ethical concerns regarding the issue. These have been grouped broadly into bioethical concerns (further classified into concerns related to harm, concerns related to access, concerns related to autonomy and choice), concerns stemming from differences in worldviews (those related to the nature of the family, social acceptability of the surrogate mother), economic concerns (those discussing development and poverty) and epistemic concerns (those invoking scientific knowledge and evidence).

What is important to keep in mind, from a critical science education education angle is that ethical principles like harm, access and autonomy in relation to an SSI like commercial surrogacy are impinged by larger social, political concerns. For instance, if we focus on the principle of harm, it is important that students apply this principle to evaluate the impact on of the technology on *all* stakeholders, in particular the most marginalized, which is the surrogate mother. In both the interviews as well as the group discussions, many students raised concerns regarding health risks the procedure may cause to the surrogate mother, while a few were concerned about the health of the child born through the procedure. There were some students who harbored suspicions towards the surrogate mother's body (whether she would be screened for STDs) or did not trust her to sustain the contract, believing that she may not give up the child. While debating on whether the technology should be accessible to all through the public health care system, it does not make sense to apply the principle of justice uncritically without paying heed to other life threatening health concerns that require subsidies. Some students raised the issue of access, but did not factor in other priorities. On the issue of autonomy, there were several instances where students pointed out that poor women are making a free choice to enter a surrogacy arrangement. That these choices are very often made under the compulsion of poverty was a fact that most students seemed to miss. Students also seemed to encounter difficulties understanding the nature of poverty and seemed to believe that surrogacy would in the long run help address it and help the surrogate mother and her family “graduate” to the middle class. These responses suggest that students are oblivious to the structural nature of poverty and the unequal status of the different stakeholders in a surrogacy

arrangement.

On whether IVF is an acceptable option or not, barring a few who questioned the very need of the technology in terms of whether having one's own biological child is necessary or not, most students were accepting of the technology and its potential to offer a solution to infertility. In certain cases, underlying worldviews and value positions (motivated by caste, religion and patriarchy) seemed to motivate students' positions on the desirability of a biological family or a social family. Some students seemed concerned about what would become of the social acceptability of the surrogate mother if she engages in surrogacy.

With regard to standpoints, as discussed, some students appeared to identify with either one stakeholder or the other in the controversy, as indicated by how they took positions that were sympathetic to the surrogate mother, or skeptical towards her. Others seemed to adopt standpoints that seemed to emanate from deep-rooted principles. It is important to further investigate what motivates these tendencies.

Students also weaved in epistemic concerns in their discussions, with several of them inquiring about the kind of risks that the procedure posed to the surrogate mother's body. Their skills to evaluate evidence related to health risks was investigated separately, and has been reported in chapter 5. Besides this, they also attempted to integrate disciplinary knowledge in their discussions. What is interesting, as illustrated in some of the examples, is how students, based on their understanding of science, suggested the redesign of the technology to suit value-laden purposes. In one example, we have a student suggesting that the technology be modified to suit the patriarchal end of expressing the fathers' traits, while in the other example, we see a student suggesting a modification of the technology premised on the beief that interference with the working of the menstrual cycle as harms the body of the surrogate mother. While in the first example, the student manifests a flawed understanding of the science as well as regressive values, in the second example, the student's understanding of the science involved was correct, and the ethical value that premised the suggested modification of the technology was based on the principle of minimizing harm. In yet another discussion, we have a student pointing out that adopting a child may be as viable an option as IVF, and discusses the role of genes versus the environment in shaping the “nature” of a child. As Nielsen (2012b) notes, students, when engaging in socioscientific deliberation most

often do not use disciplinary knowledge of science to merely convey information; in fact, they weave in science when making value-laden challenges to their interlocutors. In the aforementioned instances, as well, we find students interweaving science with values.

4.7.2 Nature of student's disagreements

I also discuss here, the kind of disagreements the students had in their group discussions and their interviews. To do so, I employ Levinson's levels of disagreements (LoDs). At level 1 and 2, there were no disagreements as such. As mentioned, several students raised queries regarding the extent of health risk posed by the technology to various users. Preliminary explorations in the interview suggested that students needed support to understand the nature and extent of risk. To this end, I (along with another facilitator) conducted a set of structured activities to elicit their understanding of different sources of evidence and their reliability (discussed in chapter 5).

Students did have disagreements that could be pitched at level 3. In some instances, we found them conducting cost-benefit analysis, where they weighed one concern against another, such as group discussions around whether IVF should be accessible to all through the public heath system. Even though this is an important issue to deliberate on, some students felt that the technology ought not be accessible to the poor because they are incapable of taking care of their children. This is obviously a prejudiced position and a teacher would need to intervene and raise questions on whether this is a desirable way of framing the question. Questions such as, is the right to procreate, a universal right or should the government funds for health care be spent on making services like IVF available through the public health care system may help students make informed decisions.

Another level 3 disagreement that students appeared to grapple with was whether the health risks posed by the technology could be traded off for the financial gains that the surrogate mother would receive by engaging in surrogacy. Students arrived at different decisions on whether the money that she was making was sufficient, taking into consideration the health risks that she is likely to endure. One of the key issues that needs to be addressed in order to resolve the disagreement would be to ascertain the levels of risk involved for the surrogate mother, as well as the acceptable levels of risk, which would in turn require a careful

evaluation of the evidence available. However, students never deliberated on the acceptable levels of risk. This may have to do with their lack of familiarity with engaging with the nature of evidence involved.

At level 4, students indicated disagreements on the basis of differences in ethical or value premises. For instance, we witnessed an exchange between a boy and two girls (Extract 43), where the boy was deeply troubled by the idea of the surrogate mothers' body being treated like a commodity and being “traded”. While one of the other participants in his group appeared to see his point of view after some persuasion, the other student remained indifferent. Handling these disagreements may prove difficult for the teacher, who may need to illuminate different points of view and ensure respect for diverse views. At level 4, we also had students raising concerns and debating on the need for technology in terms of whether a family based on genetic relationships is necessary. Here too, it may be worthwhile to interrogate views that stress the need to maintain sanctity of the bloodline as some of these appeared to come from casteist perspectives. Educators/teachers could also raise questions on the nature of infertility – whether it is a biological problem rooted in notions of genetic relationship or a social problem.

Disagreement at level 5, which involves differences that may arise due to alternative ways of interpreting a concept was also apparent in the interviews as well as group discussions, especially views which questioned the idea of a family. One student, in his interview, raised a fundamental point about the nature of the family when he suggested that one can always treat someone as one's family. He seemed to understand the term “family” differently from most other participants, who did not question the notion of family premised on genetic relationships. Students also debated on the nature of poverty and who is a poor person and seemed unable to come to a decision. Another disagreement at level 5 emerged when students debated on the nature of “experience” a surrogate mother would have, after *going through* the IVF procedure as against a doctor, who has the knowledge of the procedure of IVF (detailed in chapter 5). Disagreements at both level 4 and level 5 may not be easy to resolve as these differences often stem from considerations that arise from different ethical or value premises. However, these differences ought to be discussed in the classroom, and the teacher could help illuminate differences in premises and consideration of alternative viewpoints.

At level 6, we find students raising concerns based on the interest positions they assumed in terms of different stakeholders involved in the technology. From the perspective of critical science education, where there is an explicit commitment to equity and social justice, it might be important to get students to evaluate the technology from the standpoint of the most marginalized user of the technology. In this context, it is the surrogate mother and the risks the technology would pose to her body. Though many students took positions that were concerned about the surrogate mother's health, some found it difficult to evaluate the technology from her point of view.

It was difficult to gauge whether any of the student responses could come from deep rooted personal experiences (level 8) as our interactions with the participants were for a limited amount of time. Nevertheless, there is reason to believe that this may have a role in shaping their views at various levels. At level 9, we witnessed participants arguing on the basis of religious beliefs. Arguments at this level would be a challenge for teachers to handle, particularly those views that are regressive and reinforce notions of caste and patriarchy. It is not clear whether all the students subscribed to these notions, because some of them would often *other* these worldviews as something that the extended “society” harbors. This was evident in the debates around the desirability of a biological family vis-a-vis a social family. As Levinson (2007) points out, arriving at a consensus for participants who argue on the basis of differing world views is difficult. So the task for the teacher would be to encourage dialogue across different worldviews on both the sides and facilitate the development of empathy and mutual tolerance. In this context, it may also be important to keep in mind the point made by Levinson (2007) where he asserts that racist, sexist or other anti-minority views are not to be viewed as controversial since views that oppose equality of human beings are not rationally defensible, and these views cannot be aired in a classroom context, in a climate of mutual respect and tolerance. Therefore, views that are openly prejudicial need to be challenged by the teacher.

To sum up, Levinson's LoDs were helpful as a theoretical framework to parse out the issue of commercial surrogacy in terms of multiple levels. We witness students bringing in a wide range of social, ethical and political considerations regarding the controversy, indicating a spectrum of worldviews. What is worrisome is the existence of student discourses that support

inequalities related to class, caste and gender. Working with students who harbor reactionary perspectives may prove to be a challenge. There were certain views that could be associated with minority groups as well (those related to religious beliefs, for instance), which will need to be carefully and sensitively addressed, if brought up in the classroom.

Table 4.1 Commercial surrogacy discussed in terms of Levels of Disagreement

LEVEL 1 & 2	LEVEL 3	LEVEL 4	LEVEL 5	LEVEL 6	LEVEL 8	LEVEL 9
-Health risks to the surrogate mother, biological mother, child -Success rate of IVF procedure	Concerns related to affordability and access	Does surrogacy amount to trading the body? And is this acceptable?	- What constitutes 'family'? Does lending genetic material amount to parenthood? Need for genetic family (ensured through ART) versus Need for social family (ensured through adoption) - Are the surrogates making a 'choice' to rent their wombs? Is a choice motivated by poverty a free choice? - Are the surrogate mothers being exploited? Can someone choose to be exploited?	If participants look at commercial surrogacy from the interest position of commissioning parents, they may see it as justified. But from the perspective of surrogate mother, is it justified?	An adopted person may have strong positions on the issue	Worldview differences stemming from Religious concerns that view IVF/ Surrogacy as unacceptable

Description of the levels in Table 4.1 (as discussed in Levinson, 2006):

Level 1 Disagreement related to evidence which could in principle be forthcoming would be available at some point

Level 2 Disagreement related to evidence which is "conflicting, complex and difficult to assess"

Level 3 The criteria needed to resolve the controversy may be agreed upon. But disagreement on weightage needed to be given to these criteria

Level 4 Disagreement related to lack of consensus between the parties on ethical premises

Level 5 Disagreement related to difference in interpretation of concepts involved.

Level 6 Disagreement related to different perspectives that arise due to difference in interest positions

Level 7 According to Levinson (2006), this category can be subsumed under level 9. Hence, it is not discussed in the table above

Level 8 Disagreement due to differing 'total experiences' of people involved.

Level 9 Disagreement related to the entire frameworks of understanding/world-view differences

CHAPTER 5

STUDENTS' NEGOTIATION OF COMMERCIAL SURROGACY: EVIDENCE EVALUATION

5.1 Overview of the chapter

There is general consensus that one of the skills that would help informed decision making in socioscientific issues is the ability to evaluate complex and conflicting evidence (Kolstoe, 2001b; Kolstoe, Bungum, Arnesen, Isnes, Kristensen, Mathiassen & Ulvik, 2006; Ratcliffe, 1997; Sadler, 2006; Wu & Tsai, 2007; Zeidler, Sadler, Simmons, and Howes, 2005). As the findings in chapter 2 reveal, these are not imparted through the existing science curriculum. In this chapter, I lay out what these skills are and present findings from an empirical study that investigated students negotiation of evidence related to the socioscientific issue of commercial surrogacy. That said, it is important to keep in mind that evaluation of evidence constitutes only a part of engaging with socioscientific controversies. Nielsen (2013a), for instance, points out that socioscientific deliberation is not about what is true, but what to do and hence requires the integration of values as well as facts. Students need skills to integrate factual information and other kinds of evidence, i*f they perceive it as necessary*,in their deliberations on socioscientific issues.

As already noted in the previous chapter, in the interviews, some students were probed regarding how they would go about assessing the health risks that IVF would pose to surrogate mothers. It appeared that students were confused about how to go about investigating this systematically. Thus, in order to get a clearer picture, a series of structured activities were carried out with a small group of students where they conducted Internet research, evaluated primary and secondary sources of evidence and examined media articles. These results are reported in this chapter.

5.2 Review of literature

Plenty of research has been devoted to investigating the ways in which students engage with evidence when they evaluate socioscientific issues. What perhaps needs to be understood, at the outset, is that the science in socioscientific issues is uncertain and unresolved. This is in striking contrast to textbook science, where it is presented as authoritative, true knowledge (Dori & Tal, 2000; Kolstoe, 2000, Roth & Désautels, 2004). Students need to understand that dispute is at the center of science, which would in turn involve an understanding of how scientists collect and interpret evidence and why they disagree with each other (Hodson, 2011).

In a seminal article, Kolstoe (2001b) unpacks what distinguishes "content transcending knowledge" required to engage with SSIs, which he defines as "knowledge, or skills and attitudes that do not have their focus on the products of the scientific community: the concepts, laws, and theories" (p.292). He identifies eight topics under which these can be discussed. As the original topics were perceived as having overlaps, they have been concisely summarized as follows:

1) The science in socioscientific issues represent cases of frontier science – tentative and uncertain, which is very different from "textbook knowledge" that discusses certain knowledge comprising canonical laws, theories and can be verified through laboratory activities.

2) Decision making in SSIs does not happen solely within the domain of science and ought not to be left to experts alone. As Allchin (1999) points out, science may help illuminate certain causal relationships or unforeseen consequences (risk) in ethical dilemmas but whether the risk is *acceptable* or not is eventually a value based decision.

3) Vested interests (social, political, ethical and economic) and values drive the gathering and interpretation of evidence in socioscientific issues.

4) Scientific models are context bound; even if there is established theoretical knowledge on an issue, say the levels of health risk associated with a certain amount of radiation, this knowledge is limited to a certain context and may be subject to revisions.

5) Evidence that may be brought to bear on socioscientific controversies are of two kinds. These include scientific/statistical evidence, which, in Levinson's (2007) words is, “public, inter-subjective and open to validation” (p.79) and anecdotal evidence that is “vitally important in bringing to light local and intractable data which the formal generalized models of scientists cannot account for” (p.79). Both these kinds of evidence have a role to play in illuminating a socioscientific controversy and have their own strengths and limitations.

6) Attitudes such as the willingness to suspend belief and a critical attitude to presented information are necessary when engaging with SSIs.

In order to assess the complex and conflicting evidence related to socioscientific issues, students also need critical reading skills to evaluate the reliability and validity of evidence as well as understand how it has been interpreted to construct claims. Hodson (2011) breaks down what constitutes critical reading skills:

> Proficient and critical reading, whether first order or second order literature, involves more than just recognizing all the words and being able to locate specific information; it also involves the ability to: (i) determine when something is an observation, an inference, a hypothesis, a conclusion or an assumption; (ii) distinguish between an explanation and the evidence for it; and (iii) recognize when the author is asserting a claim to ‘scientific truth’, expressing doubt or engaging in speculation (p. 46)

Existing literature that investigates students' understanding of theory and evidence suggests that the ability to model evidence varies with age (Driver, Leach & Millar, 1996) as well as the context of the task, and is domain-specific (Samarapungavan, 1992). Naïve models view evidence and explanation/claims as indistinguishable (Goldman and Bisanz, 2002) and do not make distinctions between data, hypothesis and predictions (Sadler, Zeidler & Chambers, 2004). Students often equate evidence with information that tells us how things are, as opposed to considering evidence as providing a basis to build conjectures about *what could be* (Driver et. al, 1996). Further, research also suggests that students accommodate evidence that fits with prior beliefs and hold on to these beliefs, even when the data contradicts these beliefs (Zeidler, 1997; Zeidler, Walker, Ackett & Simmons, 2002). Critical reading skills

ought to enable students evaluate between rival claims, check for inconsistencies between reports and gather more information, if needed, to resolve inconsistencies (Hodson, 2009).

Another relevant area of research that could help make sense of how students evaluate information when negotiating socioscientific issues is personal epistemology. It offers models of epistemological development of students as they progress through high school to college (Hoffer & Pintrich, 1997). This area of research also suggests that students go through shifts in their epistemological thinking regarding the nature of knowledge and knowing, from a realist view that sees knowledge as absolute and certain, to a position of relativism where all knowledge claims are viewed as being at par with each other and finally, to a position which views individuals as active constructors of meaning, where knowledge is critically evaluated based on the available evidence and warrants. Indeed, very few reach the most sophisticated position, but research evinces that all these different stages of epistemological development have been observed in high schoolers.

Another factor that plays a role in students' engagement with evidence is trust. In Kolstoe's (2001a) study, When high schoolers evaluated knowledge claims, they were more interested in the credibility of researchers who made the claims, than in engaging with the evidence. This finding, however, contradicts the findings of Korpan, Bisanz, Bisanz & Henderson (1997), whose sample of students seemed more interested in the methodology used to establish the claim, than who advanced it. Sadler (2004a) believes that the discrepancy in their findings may have to do with the age of the participants as Korpan et al.'s (1997) study was conducted with a sample of university students.

This brings us to the question of what students need to look out for when they evaluate reports. Hodson (2011) breaks this down in terms of a checklist of questions:

> ...who conducted the research and where was it conducted? How was the research funded? Was the research sponsored and, if so, by whom? What is being claimed? What evidence supports the claim? How was the evidence collected? How was the evidence interpreted? What assumptions are made and what theories are used in arguing from evidence to conclusion? Do the authors use well-established theory or do they challenge such theories? Are alternative interpretations and conclusions

> possible? What additional evidence would help to clarify or resolve issues? Have there been other studies conducted by these scientists or by others? (p. 38)

Besides the above, understanding how to distinguish and evaluate diverse sources of secondary information is also vital, which include newspaper articles, textbooks, internet web pages and journals. Goldman and Bisanz (2002) note that there are three kinds of scientific communication —communication in scientific journals which is shared between scientists, that which gets reported in the media—newspapers and Internet and finally, what gets printed in the textbooks. Students need to understand the differences between these different three kinds of communication. This chapter reports results from some exploratory activities that students engaged in when they were asked to evaluate primary as well as secondary sources of evidence.

Drawing from Jerome Bruner, Levinson (2007) argues that there are two broad ways of structuring reality (modes of thought) – the logicoscientific and the narrative modes. While the narrative mode helps in illuminating one's point of view when there are fundamental differences in worldviews (through anecdotes and stories), the logicoscientific mode deals with explanation and illuminating causal relationships. The means by which the two modes of thought can be deployed to convince the opponent are different: while the narrative mode works by generating empathy and getting the opponent to see the world from the arguer's point of view, the logicoscientific mode appeals to reason and logic. Since SSIs are characterized by uncertainty, risks and disagreements on values; Levinson believes that when negotiating these issues, scientific knowledge (which represents the logicoscientific mode of thinking) will need to be employed in concert with anecdotal knowledge (represented by the narrative mode). The role of anecdotal evidence in socioscientific controversies have been highlighted by several science studies scholars (Wynne, 1989). Anecdotal knowledge “has the capacity to act as ‘bridging’ evidence between technical assertions and personal, social and political understandings” (p.79). In line with this perspective, students attitudes towards knowledge sources that are anecdotal in nature (how they view the surrogate mothers' experiences of IVF procedure, for example) have been explored in this study.

5.3 Methodology

The methodology employed involved group discussions with eleven students, 8 girls and 3 boys[22]. These students were in class XI (roughly 16 years old), at the time the study was conducted. The students initially responded in writing[23] to three worksheets (Appendix VII-IX). The probe, as well as the questions were introduced and explained. This was followed by discussions in individual groups. They were then invited to discuss their responses with two facilitators. Table 5.1 provides a succinct description of the worksheet used and their purposes.

The first question that the students responded to was raised in the context of a fictitious scenario (see Appendix VI, question no.4) wherein a poor woman named Jyoti, considering surrogacy as a job option, approaches them to find out whether it is a safe option for her. She works as a domestic help in five houses and has three children of her own. Students were then asked to list different sources from where they could find information regarding health risks. In response to this question, students identified three sources of information- a) Doctor, b) Surrogate mother c) the Internet[24].

Following this, students searched the Internet for various websites that would have information on the health risks that engaging in surrogacy might pose to them (Appendix VII). They then responded to a worksheet (Appendix VIII) which probed them on how they understood the reliability of expert knowledge (doctor's knowledge) vis-à-vis non-expert knowledge (surrogate mother's knowledge). They also evaluated different secondary sources of information which included newspapers, medical textbooks, school and college textbooks as well as research journals. Following this, they were provided another worksheet (Appendix IX) which probed their understanding of the nature of evidence in two newspaper articles (edited slightly to improve readability) expressing contradictory views on surrogacy. The students were given about 1-2 hours to read, fill up, and discuss each worksheet in groups. There were three groups of three boys, three girls and five girls each. Following this, they

22. There were 13 students on day 1, during which worksheet 1 and 2 were discussed, two dropped out on day 2, bringing the number down to 11.

23. Out of eleven worksheets, only ten were analyzed because one student seemed to have difficultly in expressing her thoughts in writing. Her responses in the group discussion, where she used Hindi in her discussions, has been considered for analysis.

24 Students identified primary as well as secondary sources of information.

discussed their responses with the facilitator that spanned half an hour to forty minutes and involved members from all groups.

In the sections that follow, I discuss students responses to the aforementioned evidence evaluation tasks under two broad heads: students evaluation of primary sources and secondary sources of evidence.

Table 5.1 Details regarding worksheets used in the study

Worksheet	Purpose
Worksheet 1 (Q.4) Fictitious scenario involving a potential surrogate mother who wishes to get information on health risks posed by the procedure. She approaches the student to find some information for her. Students are asked to list sources of evidence that they would look for.	To elicit students' understanding of primary and secondary sources of evidence
Worksheet 2 Internet research activity where students were asked to locate reliable websites that host information on health risks related to surrogacy	To elicit students' understanding of how to evaluate secondary sources of evidence: Do students critically examine the sources from where information is derived? Do they evaluate the websites in terms of who hosts them?
Worksheet 3 Students were asked to compare between primary sources of evidence: the doctor and surrogate mother. Students were asked to assess 5 sources of secondary evidence and judge their reliability: Newspapers, school and college textbooks, Medical textbooks and Research Journals.	To elicit students' understanding of the distinctiveness and validity of different sources of knowledge. To elicit students' understanding of the nature and reliability of sources of information
Worksheet 4 Students were asked to compare two newspaper articles. While the first article (unfavorable to surrogacy) was written in a more logico-scientific style, the second article (favorable to surrogacy) was written in a more flowery, sensational style, with little evidence, and more rhetoric.	To understand how students use evidence in their evaluation of claims. Do they evaluate sources of information?Are they sensitive to framing effects? Do they see through rhetoric? Are they ready to confront their biases?

5.4 Student's evaluation of primary sources of evidence

An important goal of critical science education is to ensure that students are free of prejudice, and are open to a range of knowledge sources, particularly those of the marginalized, who are unschooled in the dominant, logicoscientific ways of presenting evidence. Yet, this does not mean that students accept every knowledge source uncritically. In the exercise reported here, students were provided a worksheet wherein they were asked to make an evaluation of the reliability of the evidence that would be gained by talking to a surrogate mother as well as a doctor regarding health risks associated with the IVF procedure (see worksheet 3, Appendix VIII). They were asked to list the advantages as well as the disadvantages of each of these sources of evidence.

5.4.1 Views on expert knowledge

All students listed advantages of asking an expert (a doctor) regarding the health risks posed by the procedure. These involved very emphatic responses that viewed the doctor as capable of clearing all of the surrogate mothers' doubts, as someone who renders a sense of safety and assurance, and as being knowledgeable due to his or her education and experience. About half of the (5/10) students raised disadvantages of asking an expert. These responses involved two kinds. The first pointed to a possible bias in the expert's opinion because of vested economic interests (2 boys) as in the following response:

EXTRACT 45

> ...There can be a case that if the doctor wants to keep his/her hospital reputation at high/top level he may just give its (IVF) benefits rather than that of its risk. (GD_2 P_1)

The second category of responses point to a lack of personal experience of the procedure as being a shortcoming in expert knowledge (3 girls). e.g.:

EXTRACT 46

> ...This cannot be reliable as the doctor can only give information in medical point of view and cannot give one experience which the surrogate mother faces. (GD_2 P_7)

5.4.2 Lay knowledge

On the knowledge of the surrogate mother, all students believed that her understanding of the IVF procedure and the risks associated with it would be valid and important, being personal and experiential in nature. Nevertheless, four students expressed reservations regarding the trustworthiness of her knowledge. One student felt that her lack of education could be a reason why she may not articulate her problems appropriately:

EXTRACT 47

> ... sometimes if we interview a surrogate mother who is not well educated and does not have proper information about such type of surrogacy risk. Then it is not reliable. (GD_2 P_1)

It is not clear from the above statement why the student believed that the surrogate mother's lack of educational exposure would make her inarticulate. The same student, in a group discussion, found himself challenged by another group member on this point:

EXTRACT 48

(GD_2 P_1 reads his response)

GD_2 P_2 :	(incredulously) How can ... surrogate mother will not know anything?
GD_2 P_1 :	if she doesn't know what is there other than...
GD_2 P_2 :	This is something fake yeah … how can the surrogate mother not tell her experience?... if a person is working in an MNC (Multi National Company) and you ask him what he had done … and a person says, “Hi dude! . ..nothing”
GD_2 P_4 :	hahaha.. “hi dude, nothing”... good example

Above, we witness GD_2 P_2 dismissing GD_2 P_1's response by posing a seemingly ridiculous analogy of interviewing a person working in a multi-national corporation (MNC) about his job, and him not being able to answer. The analogy is interesting because GD_2P_2 assumes that a surrogate mother's knowledge of her profession would be similar to that of an employee in an MNC, while GD_2P_1 believed that being uneducated would make her knowledge of the procedure limited. It should also be noted that GD_2 P_2 completely cut short GD_2 P_1 and ridiculed him. This violates communicative norms that would ensure respect for all points of view in a discussion.

Other participants (2) felt that the experiential knowledge of the surrogate mother regarding the IVF procedure is limited to her body and is hence not generalizable:

EXTRACT 49

> ...it may not be reliable as the woman knows only the problems that she faced during, before & after pregnancy and it is also possible that she may not have undergone such health problems. (GD_2 P_{11})

One student noted that the surrogate mother would only report negative experiences associated with the procedure and hence it would be partial:

EXTRACT 50

> This information may not be reliable because interviewing a surrogate mother will only tell her about the pain and the disadvantages. And how she felt. The person will not get up to the mark info (GD_2 P_4)

5.4.3 Comparison of expert and lay knowledge

On the question of which of the sources of knowledge is more trustworthy, most students believed that both were equally trustworthy. Two students indicated that the doctor is more trustworthy because of his expertise:

EXTRACT 51

> I think the doctor is more trustworthy. Even if the doctor has not undergone that phase, he/she knows the best about the health risks involved in the activity. The doctor can tell us about the medications required before, during and after the delivery. He knows everything about the precautions which can be taken and the cure of the problems. Whereas, a surrogate mother who is experienced knows only about the medications she took and the pain but she may not be knowing everything about the problems, even she follows what the doctor tells her. She doesn't have the whole information about it. (GD_2P_5)

There were two students, on the other hand, who felt that the surrogate mother is more trustworthy on account of her personal experience of the procedure:

EXTRACT 52

> ...The surrogate mother is more trustworthy than the doctor. She had *experienced* (emphasis added) and the doctor had only *concluded* (emphasis added) the

> precautions, risks etc. will be involved. A surrogate mother can explain each and everything that she faced during pregnancy as she had done it. A doctor is simply a source, he might have know the thing that will help her. (GD_2 P_2)

Here, the student uses the word “experienced” to talk about the surrogate mothers' knowledge, but uses the word “concluded” to talk about the doctors' knowledge. Arguably, he meant to say that the doctors' experience of the IVF procedure is second hand, while the knowledge of the surrogate mother, derived from personal experience of going through the procedure is distinct and superior to that of the doctor.

In a group discussion involving four girls, two students had a heated debate on whether the doctor or the surrogate mother is more trustworthy as a source of evidence:

EXTRACT 53

GD_2 P_7 :	But doctor knows most..because ... he ... eh eh
GD_2 P_{13} :	No, but he has not experienced it
GD_2 P_7 :	But he has exp?? ... but he has not exp?? (groping for words)
GD_2 P_7 :	But … but surrogate mother is only ... first time she has done ... if only first time she has done surrogacy ... then she is not as experienced as doctor
GD_2 P_{13} :	No, But the surrogate mother has herself undergone the procedure... she knows what has happened to her...
[Some conversation that is irrelevant]	
GD_2 P_{13} :	But surrogate mother has herself undergone it
GD_2 P_{11} :	Both are equally (trustworthy)
GD_2 P_7 :	Yeah ... yeah ... they (doctors) do it daily
GD_2 P_{13} :	Do it daily ... in what sense?
GD_2 P_7 :	He will clearly articulate what all is there ... the doctor
GD_2 P_{11} :	He knows about the experiences
GD_2 P_{13} :	He has not experienced it
GD_2 P_{13} :	experiencing something and saying something are different

Here, we have an interesting sequence of exchanges between GD_2 P_7 and GD_2 P_{13} where they fundamentally disagree on what they understand by “experience”. While GD_2P_7 believes that

the doctor has more experience because he routinely conducts IVFs in his clinic, GD_2 P_{13} vehemently disagrees, pointing out that going through the procedure and "taking about" it are two different things. Probably what she meant to articulate is that the knowledge of the doctor who only conducts IVF routines is distinct from the experiential knowledge of the surrogate mother, who undergoes it and there is a need to distinguish between the two. This exchange is typical of a level 5 disagreement in Levinson's scheme (discussed in chapter 4), as students disagree on the meaning of a concept involved, which is, in this case, "experience".

Figure 5.1 below is a compact depiction of students views on advantages and disadvantages of expert and lay knowledge.

Figure 5.1 Students' views on lay and expert knowledge

5.4.4 Views on establishing empirical adequacy of primary sources

Students were also asked whether interviewing one surrogate mother or one doctor is sufficient to arrive at a conclusion regarding the health risks that the technology may pose to the surrogate mother. The purpose of the question was to understand whether the students knew how to systematically collect data and conduct investigations on the issue. Students categorically stated that interviewing one surrogate mother or doctor will not suffice. While five students stated that interviewing 2-5 surrogate mothers/doctors should be satisfactory, two students suggested conducting a survey or examining the

statistics available on the matter. However, they lacked clarity about how to go about establishing a credible claim on the health risks posed by the procedure. See, for instance, the following group discussion involving a facilitator and a girl student:

EXTRACT 54

GD_2 P_8 :	We need to consult two to three more doctors and two to three more surrogate mothers and then..
Facilitator 1 :	2 to 3 will do?
GD_2 P_8 :	Yes, will do
Facilitator 1 :	Okay
GD_2 P_8 :	Yeah, 2 to 3 means a common figure we can make out … average...
Facilitator 1 :	How do you make out?
GD_2 P_8 :	Some points will be common, the mothers will be facing .. some common ... some similarities and side effects like that and even when we visit doctors, its like a survey we are doing, so even what all doctors said, what all conditions are there in clinic we can come (to a) conclusion to it that are all the clinics following the same procedure... these things...(and) we could conclude
Facilitator 1 :	Okay
GD_2 P_8 :	And then, we still feel that we should study some medical books related to this topic, take opinions from different more common people about this and,
Facilitator 1:	Why more common people?
GD_2 P_8 :	Common people like our parents,some of our neighbors ... about this like
Facilitator 1:	So what will they tell you which you (do not) know?
GD_2 P_8 :	We could... they might tell us about ... “yeah, once we also heard about this type of case”, even they could suggest something..
GD_2 P_2 :	But they can suggest some wrong information also, no? ... if they don't know?
GD_2 P_8 :	*Thats upon us that which information we should consider reliable* (emphasis added) thats upon us but its not that we will miss something, we shouldn't miss something so...
Facilitator 1:	Why would?..I mean..the point that he raised is..
GD_2 P_8 :	Yesterday, I went to my mother and asked even her, so she came up with some of the examples because she is a very good news reader...newspaper ... so that we don't get time, we don't even touch

> newspapers nowadays, but she reads newspapers, watches television so she has a good idea about it she can tell me about some statistics ..yeah.. these many people are...

In the above exchange, we find GD_2 P_8 stating that one needs only to ask 2-3 doctors or surrogate mothers to arrive at a conclusion regarding the health risks incurred by the IVF procedure. In addition, she believes that asking a knowledgeable person (in this case, her mother), who is known to her personally, would help establish the reliability of a claim. But the ultimate judge is herself, as evident in the statement, “thats upon us that which information we should consider reliable”, advocating a radical subjectivity with regard to evaluating the reliability of information. It is important to mention here that she suggested a similar procedure, even when she discussed how to establish reliability of a claim in the Internet, wherein, eventually, one has to go by what one knows about the issue, in this case, real life pregnancies.

To sum up, the results suggest that most students viewed the nature of knowledge that the doctor and the surrogate mother bring to bear on the experience of IVF, as distinct. Yet, they differed in their perceptions of which kind of knowledge is more robust or reliable and offered different justifications. All students acknowledged that the surrogate mother's knowledge gained from undergoing the IVF procedure would be different in nature from the doctors' knowledge of the matter. Some students articulated the difference between the two in terms of generalizability, pointing out that the surrogate mothers' knowledge is restricted to her body, which makes it limited, while another student believed that a surrogate mother would only report negative experiences associated with the procedure. Another student articulated the difference as that between experiencing the procedure first hand and theorizing about it (he used the word “concluded”). A similar kind of distinction was raised by a girl in a heated group discussion involving five girls, where she articulated the difference as between experiencing the IVF procedure and speaking about the procedure, possibly hinting at the difference between declarative, abstract knowledge and experiential knowledge, though she did not use these terms as such to express it. As regards who would be more trustworthy, most students believed that both sources of evidence were equally trustworthy while four students differed. Among these, two students believed that the surrogate mother would be more trustworthy due to her personal experience of the procedure, while two others viewed the

doctor as being more trustworthy because of his/her experience and superior knowledge. These findings point to the fact that students do not discriminate between the two sources of evidence and critically evaluated both.

5.5 Views on secondary sources of evidence

This exercise was done to gauge the ways in which students evaluate the credibility of different sources of secondary evidence. In one activity, students evaluated various Internet websites carrying evidence on the health risks posed by the procedure to the surrogate mother (Appendix VII). In another activity (Appendix VIII), students were provided the task of rating five secondary sources on a scale of 1-5[25] and to justify their decision. The sources that they considered included newspaper reports, school and college textbooks, medical textbooks and research journals.

5.5.1 Internet research

As mentioned, students were initially presented with a fictitious scenario wherein they were required to help thirty two year Jyoti, an aspiring surrogate mother, with finding out if and whether health risks are posed by the IVF procedure. Students came up with various ways to help her, one of which was to look up the Internet for information on potential health risks. They were then instructed to form groups and look up information online on potential health risks, as well as fill up a worksheet (Appendix VII). In the worksheet, they recorded details of the keywords they employed for their searches and the selected web pages (they were asked to identify 5-6 reliable websites). They were also asked to briefly justify why they believed that the websites were reliable. Following this activity, all groups together discussed their findings with two facilitators.

a. Keyword Searches

Analysis of the keyword searches done by each group reveals that two out of four groups used five keywords in their searches, while the other two used just one keyword in their searches. Three out of the four groups specifically searched for health risks posed by the IVF procedure in their keywords. For instance, one of the keywords used by group 1 was “medical risks of

25 The rating exercise was carried out solely for the purpose of getting the students to think about the reliability of each source of information, not to get them to compare across sources.

surrogacy", while group 2 used the keyword " harms to surrogate mothers". Only one group used a non-specific keyword; "Surrogasse [sic] and its effects in vitro fertilization". Two of the groups also tried to look for more specific information on surrogacy in India: Group 2 used the keyword, "commercial surrogacy in India" and "Indian surrogate mothers" while group 1 used "surrogacy Indian medical journal".

b. Criteria employed to evaluate the websites

The websites that the students selected include commercial websites, those hosted by for profit organizations, wikipedia and a government website. In the whole group discussion involving facilitators, some students struggled to furnish justifications for why they found the websites reliable. For instance, see the exchange below:

EXTRACT 55

Facilitator :	Why did you select livestrong.com? Why did you find it useful?
GD_2 P_5 :	Ma'am we searched for many websites ... but we found it ... I don't know why … but we found it trustworthy..

Other students came up with criteria that would help them establish the reliability of a website. For instance, a boy, when probed regarding how they concluded the reliability of a website said, "we referred to several sites and they had the same thing which, which is here" (GD_2 P_3). He appeared to believe that if the same information can be verified in multiple websites, it would be correct and consequently, the website would also be reliable. I term this criteria *concurrence*.

Another student said that the reliability of a piece of information can be established if it coincides with something that one knows or experiences first hand, as reported in the exchange below:

EXTRACT 56

Facilitator :	So why do you find this site believable?
GD_2 P_8 :	Because, some of the side effects were really real … as we know about some real pregnancy experiences … so in that we have seen some women who feel nausea, who have back injuries...these all things we have gone through … and this site has those things … so we found it...

Facilitator : so you feel that some of these symptoms … are similar to ...

Students : (chorus) Their real life experiences...

Facilitator : That's why you find it reliable...

I term this criteria *corroboration*. In yet another exchange, another student came up with this criteria:

EXTRACT 57

Facilitator : Why did you find this reliable?

GD_2 P_9 : The sources are given ...

Facilitator : The sources are given … So (but) some of the other websites you were talking about … which you have shown me ... they didn't have any of the sources listed..

GD_2 P_9 : No Ma'am, most of the symptoms were actually coinciding with the symptoms which we normally see in pregnancy...

Facilitator : So that's why you trusted it?

GD_2 P_9 : Yeah ... 'cos surrogate mother is actually getting pregnant … thats what the symptoms are … mostly be the same..

None of the students raised the importance of examining the sources from where the information is collected, until it was specifically raised by the instructor:

EXTRACT 58

Facilitator 1 : But then, where do these sites obtain this information from? Like.. most sites have listed (symptoms)..like the Canada one (Canadian website) that you talked about..that site has also written nausea.. abdominal pain... but then.. why would you believe that website?

GD_2 P_2 : Ma'am, because there is a report given..that SAMA's report ... she has given a report..can we read now ... from the starting ... there is a report by a woman ... a report by SAMA ... she has given the experience (Here, the student confused the name of an organization with the name of a person)

Facilitator 1 : Why would a report given by SAMA be of use?

In the discussion that followed, students were informed that SAMA is an NGO that concerns itself with women's health issues. Only after more probing did the students get down to

examining the sources and the nature of information reported by the website, which was based on a survey:

EXTRACT 59

Facilitator :	You found this reliable..when I asked you why this is reliable ... you mentioned something about a report by SAMA ... I wanted you to elaborate on this ... you are not very sure about it, is it?
$GD_2\ P_3$:	This may be a controversial topic and they thought ... the organization thought lets see what is this ... so they did a survey and they gave a report
Facilitator 1 :	OK ... what is a survey?
$GD_2\ P_3$:	The survey is about the surrogate ... the mothers ... the surrogated mother..
Facilitator 1 :	What do you *mean* by a survey?
$GD_2\ P_3$:	They see a lot of women, they ask them what is your condition, and how is it like to be a surrogate mother ... and they ask many women ... and in a large scale ... they made a report and they gave their conclusion about it..
Facilitator :	Why is a survey useful?
$GD_2\ P_3$:	It gives us a broad aspect (picture) of surrogacy in India

Another student, $GD_2\ P_2$, believed that reliable websites were faster than the “fake” websites, as in the response below:

EXTRACT 60

> While searching also the government and private websites are faster ... than the fake..that means that the websites are actually ... we can say that..($GD_2\ P_2$)

Students also brought forth concerns related to the authenticity and reliability of government vis-à-vis commercial websites:

EXTRACT 61

Facilitator 1 :	So how do you ensure that a website can be trusted? Or it is written right (pause) ... would you disbelieve all websites?
$GD_2\ P_{12}$:	No
$GD_2\ P_2$:	Actually … this is not the fake website...
$GD_2\ P_1$:	Ma'am, the website should be government approved ... or it should be

	some private hospitals ... or...
Facilitator 1:	Private hospital or government?
Some voices:	Government ...
Facilitator 1:	Which is more trustworthy?
Students :	Government
Facilitator 1:	Why?
GD_2 P_2 :	Because in the address bar you can see .gov...
Facilitator 1:	Right … but why would it be trustworthy if it is a government website?
GD_2 P_2 :	Because any fake information will not be available in government sites ...
Facilitator :1	What about private … you were saying that even private (to GD_2 P_1)
GD_2 P_1 :	In private hospitals mostly they will upload the things which they have experienced..
GD_2 P_8 :	Which are favoring to their advantages or profits ...
Facilitator 1:	So … therefore is it trustworthy?
GD_2 P_8 :	(murmuring) not much ... (others are silent)

Students appeared to believe that government websites are reliable. Though one student actually pointed out that commercial websites may host information that may support the vested interests of private companies, she still seemed uncertain regarding the reliability of these sites, while others stayed silent, indicating that they were unsure as well.

On the question of whether the information that they gathered from the Internet was enough to advise Jyoti on whether she ought to become a surrogate mother, all the groups except one reported that the information would be sufficient. The latter group believed that consulting a doctor might be necessary. In the group discussion with the facilitators, other groups also pointed out the importance of consulting a doctor about the health risks faced by the surrogate mother.

In summary, the results indicate that some students faced difficulties articulating how they established the reliability of a website, while others came up with certain criteria to evaluate the information online. One criteria was looking at whether information in a website is corroborated by information in other websites, indicating that students believed that non-conflicting knowledge about the topic is available. Another criteria was checking if the

information available online can be corroborated by real life experiences, as evident in a response which pointed out that the health risks faced by a surrogate mother would be similar to those that are a result of natural pregnancies. Students also believed that faster websites are more reliable and that government run websites are more reliable than commercial websites, but provided no justifications.

5.5.2 Views on newspapers

As pointed out earlier, students rated five secondary sources on the reliability of the information furnished by them (Appendix VIII). Among these, newspapers are one of the most accessible media sources. Regarding these, students had varying views. Three students pointed out that newspapers may manipulate or misrepresent information, as evident in this response:

EXTRACT 62

> ...I consider info from this source is reliable and non-reliable also because some newspapers print the incomplete information or sometimes bullshit. (GD_2 P_2)

Another student pointed out:

EXTRACT 63

> ...Information from newspaper is not much reliable because such information about surrogacy in common newspapers is much rarely (is rare) and is edited in most of the sources. (GD_2 P_1)

There was some debate around the issue of editing in newspapers, as in the following group discussion involving the above student and two others boys (GD_2 P_2 and GD_2 P_4):

EXTRACT 64

GD_2 P_4 :	(reads out his answer) If we give an article to the editor ... the editor check(s) it properly ... then only it goes to the printing newspaper
GD_2 P_2 :	The article … sorry, the editor … just read the information, no (?)..they will tell that the surrogate mother … there is no way of ...
GD_2 P_1 :	(interrupts) They edit...
GD_2 P_2 :	But some of them ...
GD_2 P_1 :	Yeah … if they think something is useless then … they edit...

$GD_2\ P_2$: That Hindi newspape r... whats its name ... NBA ...It was called something...

$GD_2\ P_1$: Nav Bharat Times..

($GD_2\ P_2$ laughs and turns to $GD_2\ P_4$)

$GD_2\ P_2$: Fake..

In a whole class discussion with the facilitators as well, $GD_2\ P_4$ elaborated this point to one of the facilitators:

EXTRACT 65

$GD_2\ P_4$: Because newspaper can't give the clear idea about it ... some newspapers will also have fake articles or some like that...as we were discussing … as $GD_2\ P_2$ told.. there was a news in Navabharat Times … there was news that a lady give birth to ... birds egg (not clear) … it was a fake news..

Facilitator 1 : Some newspapers are not very reliable

When the students were probed further on which newspapers they found reliable and provide reasons, many of them did not provide justifications. For example, see the excerpt below, which involved a whole group discussion with the facilitator:

EXTRACT 66

Facilitator 1 : Which are reliable newspapers, according to you?

$GD_2\ P_2$: Reliable like …. Times of India..

Facilitator 1 : Times of India is reliable?

Facilitator 2 : Why? why is it reliable?

$GD_2\ P_2$: Times of India is reliable because in my …. on my opinion.... it's a number 1 newspaper because ... as you see …. in the editorial page beyond the speaking thing... there is a biological page where all information of biology is given (the science news) means all of the ... what are the research going on in biology...stem cells ... all the information is given

Facilitator 2 : Okay.... that group (pointing to a group of girls) you were saying something about DNA?

$GD_2\ P_8$: Yeah.. even that paper is quiet reliable... as per I know

Facilitator 2 : ...and what does this group feel...which paper is reliable?

$GD_2\ P_{11}$: Times of India

Facilitator 2 : Any other?

GD_2 P_4 : One more reason is that Times of India's language is very high

Facilitator 1 : What does this group (5 girls) feel?

GD_2 P_7 : The Hindu

Facilitator 1 : Why is it more reliable?

GD_2 P_7 It's more social...

Facilitator 1 : Social news..?

GD_2 P_7 : ... and the current affairs which are … which are

In the above exchange, we find students struggling to provide evaluative criteria that that would justify the reliability of the newspapers that they named. The justifications provided are naïve, with most students merely reiterating that these newspapers are informative. One student believed that the standard of English language used in the newspaper is an indicator of reliability.

Only two students believed that the reliability of a newspaper can be determined in some way, with one student pointing out that this can be done if the same information is corroborated by another media source:

EXTRACT 67

> ...Some knowledgeable newspapers provide a good source of info. And these info can be seen in TV also. (GD_2 P_2)

The other student made a similar argument, stating that people would not buy newspapers if they were not reliable; a criteria that I term as *popularity*:

EXTRACT 68

> (On) the whole, (newspapers) might not be reliable as the newspapers manipulate some info. But most of it has to be true because people will stop buying their papers. (GD_2 P_9)

The aforementioned student is committing an *ad populum* fallacy as she appears to believe that the truth of a newspaper's claim is based on how many people buy it, or how popular it is. Two students felt that newspapers are reliable because they print the experiences of surrogate mothers or allow them to write articles. Others felt that there may not be enough information in newspapers.

To sum up, students encountered difficulties when trying to formulate evaluative criteria that would help establish the reliability of newspapers. Some students pointed out that the news gets edited and what we may eventually read may not represent the truth. However, most students seemed unsure about what makes certain newspapers reliable, with responses merely stating that they were informative, that articles written in good English make them reliable, or that having a large readership indirectly establishes the reliability of the newspaper.

5.5.3 Views on school/college textbooks

On the whole, students seemed to believe that the information in school textbooks are not adequate or reliable. A much invoked criteria was *detail*: one student pointed out that there is less scope to ask questions while another student felt that there are less practical examples. See, for instance, the following response:

EXTRACT 69

> ...school or college textbooks will not have that much information as they will define the terms in a short way. The detailed study which is expected will not be there in the textbooks. Even the interviews or cases will not be there in the textbooks. (GD_2 P_{10})

Students did not question the truth value of the information laid out in the textbooks. Three students pointedly noted that they represent the truth. See, for instance, the following response:

EXTRACT 70

> There is mostly the truth but sometimes misprint can give false information. (GD_2 P_9)

Another student wrote:

EXTRACT 71

> [I] Strongly feel that the school/college textbooks provide a good aid trustworthy information because it had been by government of India. There it can(not) be any fake information. As it gives education, there is less risk of fake information or incomplete information brought out by the government of India it has to be true. (GD_2 P_2)

The aforementioned student harbors the naïve belief that information in textbooks sanctioned by the state has to be true. The sole purpose of textbooks being to educate, the textbook and the curriculum ought to be free of ideologies.

5.5.4 Views on medical textbooks

Students on the whole were positive about the reliability of medical textbooks. They believed that it yielded reliable information for various reasons. An often invoked criteria was *authority*, that medical textbooks are written by professionals for those training to be professionals, as in the response below:

EXTRACT 72

> The medical textbooks are written by the advice of the doctors and professionals so the information can be reliable. They give the detailed information (GD_2 P_5)

Similarly, another student wrote:

EXTRACT 73

> ...reliable as many students are learning from these textbooks & follow its rules & become big doctors (GD_2 P_6)

Another student believed that medical textbooks would be reliable because they would have case studies:

EXTRACT 74

> medical textbooks will have detailed study of the cases in a proper way (GD_2 P_{10})

One response stated that medical textbooks are reliable on account of the *purpose* for which they have been written, which is to help people:

EXTRACT 75

> These are specially designed to help people and hence need to be true. (GD_2 P_9)

Another student felt that it would be reliable as it would employ medical terms:

EXTRACT 76

> ...makes you understand about the topic in medical terms. (GD_2 P_8)

Some merely stated that it is informative, as in the response below:

EXTRACT 77

> Medical textbook is the most reliable source because in this all the information would be given and there would be more questions and answers. (GD_2 P_4)

As evident in the above responses, students provided vague and naïve justifications as to why they believed medical textbooks were reliable, which included merely pointing out that they are informative, that they are written by professionals, that they use medical terms, or that they are written with the noble purpose of helping people.

5.5.5 Views on research journals

Students largely held the view that research journals are reliable. A few of them noted that they were updated with latest findings while some others wrote that they will report experiences of doctors and surrogate mothers:

EXTRACT 78

> The information can be reliable as the doctors, surrogates themselves can tell their experiences directly. The information they give is much reliable. (GD_2 P_5)

Two students were skeptical, with one student, GD_2 P_2 pointing out that it is important to verify the information from research studies because they are ongoing :

EXTRACT 79

> ...these sources can provide new information or updated information because they are researching and writing their experiences. These journals may sometimes give out wrong /fake information because it is part of research [...] so journals are not much useful/ maybe but need to be verified. (GD_2 P_2)

Another student, GD_2 P_9 raised the criteria of *generalizability* when discussing the limitations of research journals, pointing out that these only present findings from a specific place, and hence, may not yield generalizable data:

EXTRACT 80

> People would publish their own experience of talking to people but this might be located only to a specific place which will effect the people of that place. (GD_2 P_9)

In the following group discussion involving the facilitator, we find students trying to articulate what they understand by research journals:

EXTRACT 81

Facilitator 1 :	Do you know what research journals are?
GD_2 P_{11} :	It has case studies about some science or some...
Facilitator 1 :	Case studies. OK. Apart from case studies what else would you find in the research journal?
GD_2 P_{11} :	Observations and their conclusions
Facilitator 1 :	Observations...
GD_2 P_{11} :	Statistics...
Facilitator 1 :	Statistics
GD_2 P_8 :	Yeah even … updated updated information is there what are the new technologies and everything that comes under research journal ... what particular team has researched.
Facilitator 1 :	This could be there in medical textbook (as well)?
GD_2 P_8 :	It might be there but the not the version may not be that updated.

Above, we witness a student making the claim that research journals consist of information that is ongoing, representing “science in the making” (Latour, 1987), as against what is found in medical textbooks, which is “not updated”, suggesting that the student understands that knowledge regarding any topic is changing and not static.

To sum up, only a few students indicated some understanding of the nature of information presented in a research journal. While some students were skeptical of the reliability of the information reported in research journals, pointing out that the reported research may be limited, localized to a particular area or not updated, others seemed to believe that research journals are updated with the latest findings and are hence reliable.

Figure 5.2 presents a summary of the different criteria that students employed when evaluating all the secondary sources of evidence.

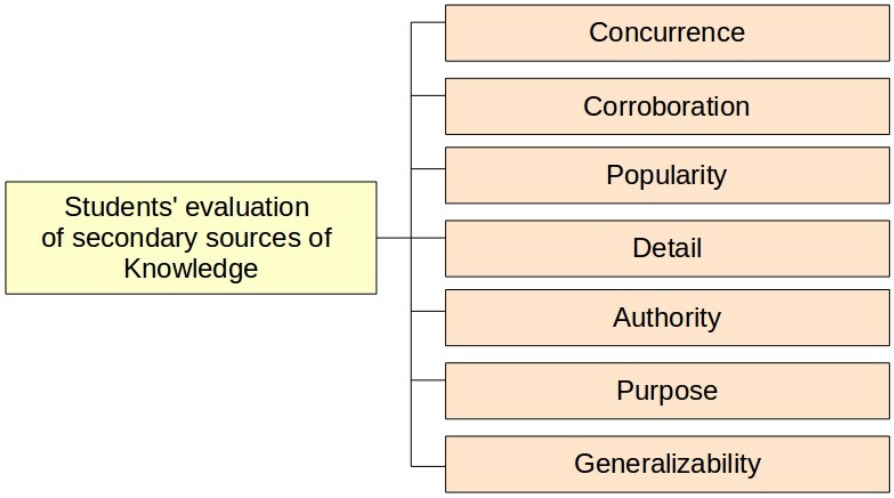

Figure 5.2 Criteria employed by students when evaluating various secondary sources of evidence

5.6 Evaluating evidence in newspaper articles

In the final exercise, students were asked to evaluate two newspaper articles (refer to the Appendix IX). This exercise was done with view to evaluating, employing a context, students' assessment of the reliability of media articles. While one article espoused an unfavorable position towards surrogacy, detailing the pain and the side effects that surrogate mothers endure during the procedure, the other adopted a more favorable stand towards surrogacy, valorizing it, and advocating the economic gains that would benefit the surrogate mother. A critical reading of this article seemed to suggest that it was written to promote a certain fertility clinic. Though it could be argued that the articles were not contradicting each other on the very same point, they were chosen because they represented different points of view on surrogacy and were also written in very different styles-- while article 1 was written in a logicoscientific style involving the discussion of the results from a survey, the second article was written in a more informal and engaging style, employing narratives of surrogate mothers. The articles also differed with regard to the samples used. The first article discussed the results of a survey that involved 12 surrogate mothers, 2 agents and 4 doctors while the second article involved interviews of two surrogate mothers and the husband of one surrogate

mother. The questions raised on the articles aimed to understand whether students were able to differentiate a piece of evidence from a claim; whether they understood how evidence is used to construct a claim, how to ascertain empirical adequacy and whether they evaluate sources of information in terms of interests, bias and other social factors.

5.6.1 Distinguishing evidence

Five students adequately identified the evidence used in both the articles[26]. The other five students had difficulty identifying the evidence. They either incompletely stated it (3) or confused the sources of evidence with the claims/findings themselves (2).

5.6.2 Evaluating empirical adequacy

Two students were skeptical of the sampling (GD_2 P_4 and GD_2 P_9) in the first article, but did not apply the criteria to the second article, which had only two interviews. For example, GD_2 P_9 wrote when evaluating the first article:

EXTRACT 82

> No, I don't think the information is enough to support the position as he speaks about India but has interviewed only a few places. (GD_2 P_9)

While evaluating the second article, however, she writes:

EXTRACT 83

> ...Yes, the information is enough to support the authors' position of being in favor of surrogacy as he has seen the patients & doctors (for) himself who seem to be very happy with the current going on situations of surrogacy in india [sic] (GD_2 P_9)

The student applies the criteria of empirical adequacy to the first article, but not to the second article. She also appears to believe that the journalist collecting the evidence first hand and "seeing" for herself makes the second article more trustworthy.

26 Interviews with surrogate mothers, doctors and agents in article 1 and interviews with two surrogate mothers and their husbands in article 2.

When comparing the articles[27], four students found article 2 more convincing than article 1. In their justifications, all of them pointed out that it was the ability to touch an emotional chord that made article 2 more convincing. For instance, they wrote that the article "beautifully describes the happiness of the surrogate mother"(GD_2 P_9), "deals with their emotions and their humanity" (GD_2 P_7) and "gives account of pain and sacrifice" (GD_2 P_6). One student (GD_2 P_8), believed that articles which contain a positive message is more convincing to her :

EXTRACT 84

> The second article proved to be successful [in] convincing me because *it had many positive aspects compared to the points and evidences mentioned in article 1* (emphasis added). I personally liked the will-power and tolerance capacity of the surrogate mothers and the fact that the money for renting their womb is improving their lives and they are able to support their family financially. (GD_2 P_8, emphasis added)

Though the student used the criteria of empirical adequacy when evaluating Article 1, she found the second article more persuasive, because she "personally liked the will power" of the surrogate mothers in the second article. The same student, when rating the first article that reported research by a women's health NGO, employed evidence based criteria in her evaluation:

EXTRACT 85

> It's the SAMA resource group putting forward their research after interviewing people involved in Indian surrogacy industry who were 12 surrogate mother, 2 agents & doctors which are many people for coming to a conclusion. (GD_2 P_8)

Another student, GD_2 P_7 also found the second article more convincing because it seemed more positive:

EXTRACT 86

> The article 2 convinces me more as it says about how the surrogate mother feels to surrogacy. Article 1 only says that the surrogate mother complaints about pains and about being kept in the dark of the procedure. But Article 2 deals with their emotions and their humanity. (GD_2 P_7)

27 For this question, only 9 students' written responses were analyzed (One student had not completed the worksheet and another students' responses were not intelligible, as she seemed to have difficulty writing and expressing herself. However, their contributions to group discussions were considered for analysis).

A particular line from a surrogate mothers' interview in Article 2 seemed to have have a persuasive effect on some students, swaying them towards looking at surrogacy favorably: "You have to lose something to gain something and what we gain is a lot more than what we lose". In the extract below, a student brings it up:

EXTRACT 87

Facilitator 1 : So what position has the author...what other things are mentioned in the article?

GD_2 P_5 : It also tells us about how the surrogate mother...the mother (who) work as surrogate, get some money and that money is very helpful to them … that is used for buying land (property)

Facilitator 1 : So basically they say the money is very useful for the surrogate mother … Is any other point raised in the article?

GD_2 P_8 : The women who undergo surrogacy are lot more happier because what they gain is lot more than what they lose

Facilitator 1 : Okay, so what is it that they gain?

GD_2 P_8 : They gain money which they can use for the betterment of their lives and families.

Facilitator 1 : Okay, so what is it that they lose?

GD_2 P_9 : The interaction with the families

Facilitator 1 : Other than that, what do they lose?

GD_2 P_{10} : All the pain and...

GD_2 P_8 : The side effects that they are taking post-pregnancy and they have to cut up their stomachs..the cesarean

Facilitator 1 : The article is making the claim that they gain more than they lose.

Two students (GD_2 P_4 and GD_2 P_{10}) believed that both the articles were equally convincing because one article discussed the positive aspects while the other article discussed the negative aspects. As GD_2 P_4 wrote:

EXTRACT 88

> ...in my opinion both the articles are correct in their ways. One shows about the pain and money and the other shows only money and no pain. As every coin has two faces. Its all depend on the women or the persons mind. (GD_2 P_4)

The above student used the criteria of empirical adequacy when evaluating the first article. But when trying to make sense of why the articles contradict each other, he puts it down to

the individual persons “mind”, which is the surrogate mother. He was the only student who tried to explain the contradiction. However, he did not bring in other considerations, such as possible vested interests and bias in reporting, but instead pinned it down to the psychological state of the surrogate mother.

Two students (GD_2 P_4, GD_2 P_9) contended that they were convinced by articles that aligned with their beliefs. For instance, GD_2 P_9 wrote, when evaluating the second article:

EXTRACT 89

> It is fairly convincing to any person that surrogacy is a great option for infertile couples as well as the surrogate mothers. The article shows how happy the mothers are for surrogacy and how well they have been taken care of. (GD_2 P_9)

Here, she makes a definitive, subjective statement that it is fairly convincing to anybody that surrogacy is a great option for all the stakeholders involved.

Similarly, GD_2 P_4 wrote, while evaluating the first article:

EXTRACT 90

> The research group has taken two states. So on the basis of two state we cant say anything. But nevertheless, I agree that surrogate mothers are kept in dark especiall[y] the country like India. (GD_2 P_4)

In the above response, we find a slightly more nuanced position where the student is skeptical of the evidence, yet he goes by his own belief that surrogate mothers' are ill-treated without providing any compelling arguments as to why he thinks so.

Three students (GD_2 P_2, GD_2 P_5 and GD_2 P_{11}) pointed out that the article that discussed the suffering of the surrogate mother was more convincing to them. For instance, see below GD_2 P_{11} 's response:

EXTRACT 91

> Article 1 convinces me more. It gives us idea about the problems faced by the surrogate mother and her feelings. Whereas article 2, it gives the reasons why a woman opt to become a surrogate mother. (GD_2 P_{11})

It is interesting that many students found the second article more compelling. The first article is written in a dry manner with facts and figures, while the second article is written in a more

informal style. Though there are only a total of three interviews in the second article, they are reported in first person. Perhaps the narratives captivated the students. In their discussion with the facilitators, students were presented with the possibility that the second article may have been written to promote a fertility clinic:

EXTRACT 92

Facilitator 1 :	... also another thing that you should have picked up on … it is (article 2) talking about Akanksha clinic, it's talking about 2 surrogate mothers from this clinic and the doctor is also being interviewed so … I *would* doubt this article a little bit because I would also think that may be the article is promoting that clinic in some sense...
GD_2 P_9 :	Because it says at some places that I found loads of women standing outside...
Facilitator 1 :	I may think about it a little bit.. it is talking about 1 clinic, 2 surrogate mothers, very happy ... talking about sisterhood...(laughter)
GD_2 P_4 :	It is taking over..it is going on over.. (sensationalizing)
Facilitator 1 :	Yeah … so the thing is ... does the article have to sound necessarily positive?
GD_2 P_9 :	No ... not necessarily
Facilitator 1 :	....but you were mentioning that...
GD_2 P_9 :	But it need not be completely positive or completely negative, it has to have a balance between
Facilitator 1 :	... But what is the truth?
Facilitator 2 :	The truth could be negative, na?
Facilitator 1 :	.... does it always have to have a balance?
GD_2 P_9 :	No
Facilitator 1 :	Ultimately what is the truth out there, what is the purpose of the newspaper article?
GD_2 P_9 :	To bring out the truth..
Facilitator :	Some kind of truth..some kind of reality..
GD_2 P_9 :	Maybe there will be more ... I feel that there will be more like *Akanksha* fertility clinic where doctors are affectionate towards their patients ... I feel ...
GD_2 P_8 :	What we feel here true is the ladies are happy because they are getting the money ... obviously anyone would be happy supporting their family so I think the ladies are happy over here...

Facilitator 1 : Then why are the ladies unhappy in the other article? In the other article most of the ladies are unhappy, right?

GD_2 P_8 : Because they face such problems like painful treatments, here they are telling that we have faced such painful treatments still they are very satisfying, the will power and the tolerance capacity is shown over here...

Facilitator 1 : Could it be possible that the fertility clinic has told them to say that they have to say these things?

GD_2 P_9 : There are many possibilities...

Facilitator 1 : So what is the truth, how do we know that?

GD_2 P_8 : If really they are getting paid like 4 lakhs or something, then its good

[...]

Facilitator : The thing is that ... of course … perhaps, the article is well written … in the sense that there is a lot of talking...

GD_2 P_9 : The article is convincing...

Facilitator 2 : The article would be convincing...we are talking about the evidence...the evidence is only 2 mothers (in article 2) while there (article 1) it was 12 mothers...and it was not just 12 mothers there were other people also...but just take the number of mothers

Facilitator 1 : It is also how you wish to write the article..there is certain purpose behind writing these kind of articles.. so I don't know ... when I read it I was thinking okay … this article is kind of trying to advertise this fertility clinic...

GD_2 P_9 : Yeah one clinic is mentioned

Facilitator 1 : One clinic is mentioned, the doctor is talking, everything is happy happy...you know

GD_2 P_8 : 110 babies … I mean they have written there successfully ...

Facilitator 1 : Babies might be produced in large numbers ... we are not talking about the number of babies here ...we are talking about the surrogate mother and her experiences of surrogacy, is she happy with it or not...

[...]

GD_2 P_8 : If they aren't feeling happy why would they again and again go back to it...

In the above exchange we find the facilitators repeatedly putting forth the possibility that a certain fertility clinic is being promoted by the second article. The fact that there was little evidence in the article to support what was being claimed was also pointed out. However, the students did not seem convinced.

In summary, when students evaluated the newspaper articles, they encountered several difficulties. Figure 5.3 summarizes some of the key findings in the section on evidence evaluation..

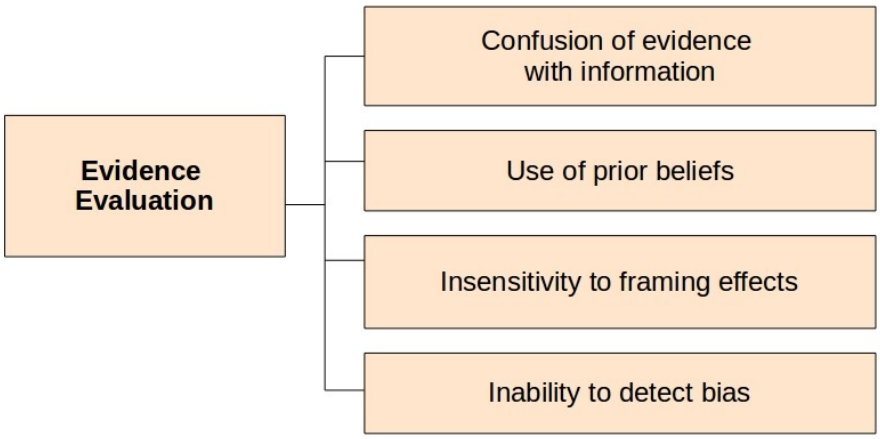

Figure 5.3 Criteria employed by students when evaluating newspaper articles

5.7 Discussion

A primary focus of the study reported in this chapter was to understand students' ideas regarding the nature and reliability of of evidence. More specifically, this was investigated in the context of how students evaluated evidence related to the impact of IVF on the surrogate mother.

In response to the question (worksheet 1, Q.4) on different ways to find out the health risks that the IVF procedure might pose to the surrogate mothers, all students categorically stated that this is possible by collecting primary (doctor and surrogate mother) and secondary sources of evidence (the Internet). Their views on the reliability and trustworthiness of both sources of evidence were investigated in worksheet 3.

With regard to the primary sources of information, all students recognized that the doctor's knowledge and the surrogate mothers knowledge of the IVF procedure are distinct and valid sources of knowledge. Some students pointed out the limitations and strengths of the two sources of knowledge. There were also some who articulated the difference very well as a

distinction between declarative, abstract, generalizable knowledge (expert knowledge) and personal, experiential knowledge (lay knowledge).

Results from the Internet research activity indicate that the criteria that students used when establishing the reliability of a website were naive. One criteria was checking if the information in a website is also present in other websites. This would conversely establish the reliability of the website as well. According to this criteria, which I term *concurrence*, non-conflicting knowledge regarding health risks posed by surrogacy is available, and it is just a matter of cross checking the information with other websites. Another criteria that a student put forth is *corroboration* – evaluation of the information in terms of one's "real life experiences" – or knowledge of the issue that one has gathered on the basis of one's own observations or in consultation with a knowledgeable elder that one trusts. Other criteria were *speed*, faster websites being more reliable, and the *credibility* of who hosts the website (government or private). Students expressed faith in government websites while they seemed unsure about the reliability of commercial websites.

When evaluating various sources of secondary information, students again resorted to naive criteria. One criteria is *popularity*; the belief that the popularity of a certain newspaper makes it reliable. Another criteria is *purpose*; as evident in responses which indicated that information in a medical textbook is reliable because it is designed to help people or that school textbooks have true information because their purpose is to educate. The third criteria was *authority,* which was evident when students invoked the expertise of the medical practitioner when discussing the reliability of medical textbooks. Finally, when discussing the reliability of research journals some students used the criteria of *generalizability*, pointing out that published research is unreliable as it is ongoing or localized to a specific sample or location. Only a few students indicated familiarity with research journals.

In summary, students showed limited and superficial understanding of how to assess the reliability of different secondary sources of information. While a few students indicated the limitations of certain sources like newspapers, school textbooks and research journals, as a whole, they lacked clarity on how to evaluate different sources of information and what criteria to employ when doing so.

The purpose of the final exercise, involving the evaluation of two newspaper articles (worksheet 4), was to get students to assess the empirical adequacy of the articles, and detect bias or vested interests on the part of the authors of the article. Regarding their abilities to use empirical adequacy as a criteria, some (5/10) confused the evidence used in the articles with the information presented, reflecting naive strategies of evaluating evidence. Among the students who did indicate some understanding of evidence based evaluation of claims, one student exhibited a strong tendency to go by her own prior beliefs regarding the issue. These findings are consistent with what is reported in Driver et al. (1996) and Zeidler (1997). Even when some students used the criteria of empirical adequacy, they did not appear to consider it necessary if the emotional content of the article appealed to them. Gardner, Jones and Ferzli (2009) discuss *framing* as a way of packaging information by the media using specific phrases, words or images to capture the attention of the audience. When the frame is weighted towards a certain perspective, through the selective use of certain details, then it is called a framing effect. They point out that frames can have a significant effect on how students engage with issues and cite evidence to suggest that negative frames tend to influence students' perspectives more than positive frames. Further, they advocate that students develop skills to negotiate media frames that they encounter in order to develop scientific literacy. In this study, however, we find students inclined towards both frames. This may have to do with their prior beliefs and commitments interacting with the framing effect of the article, and requires more research to be established. Further, Indian students have been reported to have positive attitudes towards technology (Khunyakari, Mehrotra, Chunawala & Natarajan, 2009; Sjøberg & Schreiner, 2010). This may have had an effect on their resistance to negative frames in the article. Moreover, the students who veered towards the second article were all female. These students mentioned being moved by the emotional content of the article which discussed tolerance, sacrifice and will power of the surrogate mother. No generalization can be made from a small sample of students, but future studies could explore whether gender has any influence on how a reader responds to framing effects.

Literature in personal epistemology postulates that individuals move from views of knowledge as absolute and unchanging, to views that perceive knowledge as merely personal and subjective, to a more discerning, evaluativist position that integrates the objective and

subjective dimensions of knowledge. Viewing the results of this study from this framework, one can see some of the participants adopting relativist, subjective ways of evaluating knowledge, considering evidence which conformed to their beliefs regarding the issue, and ignoring contradicting evidence. Only one student applied an evaluative stand vis-a-vis the articles. He tried to rationalize why the articles may have different positions on surrogacy, though he attributed it to the state of mind of the surrogate mother and how she might have felt at the time the interview was conducted. I believe that the student was taking a more sophisticated position when evaluating the articles where he resisted framing effects and tried to understand why there was a contradiction in what is reported in the articles. Besides this, the student justified his allegiance to what is said in one article even after noticing that the evidence is insufficient.

In terms of viewing sources of information as corrupted by interests, only one student pointed out the possibility, in the context of discussing primary sources of evidence, that the doctor's knowledge could reflect vested economic interests. Many students exhibited unquestioning reliance on authoritative expert knowledge, as evident in their responses that were uncritical of doctor's knowledge as well as their view of medical textbooks as carrying true, authoritative knowledge. Figure 5.4 illustrates the criteria students used when evaluating different sources of information.

Overall, the impression one forms, on the basis of the above discussion, is that higher secondary students' knowledge of how evidence gets collected, theorized about and presented is limited. When given specific activities to evaluate information, some of them do engage with it at a preliminary level. But they do not see how information presented in the media need to be evidence based, how to track the evidence presented in these articles to their sources, and also detect bias and vested interest in the information. The study points to a lack of basic media literacy among higher secondary students and the need to impart skills to evaluate conflicting media reports, synthesize their own own perspectives on controversial topics based on a critical reading of information as well as detect bias, vested interest and so on. These skills are vital from the point of view of critical science education.

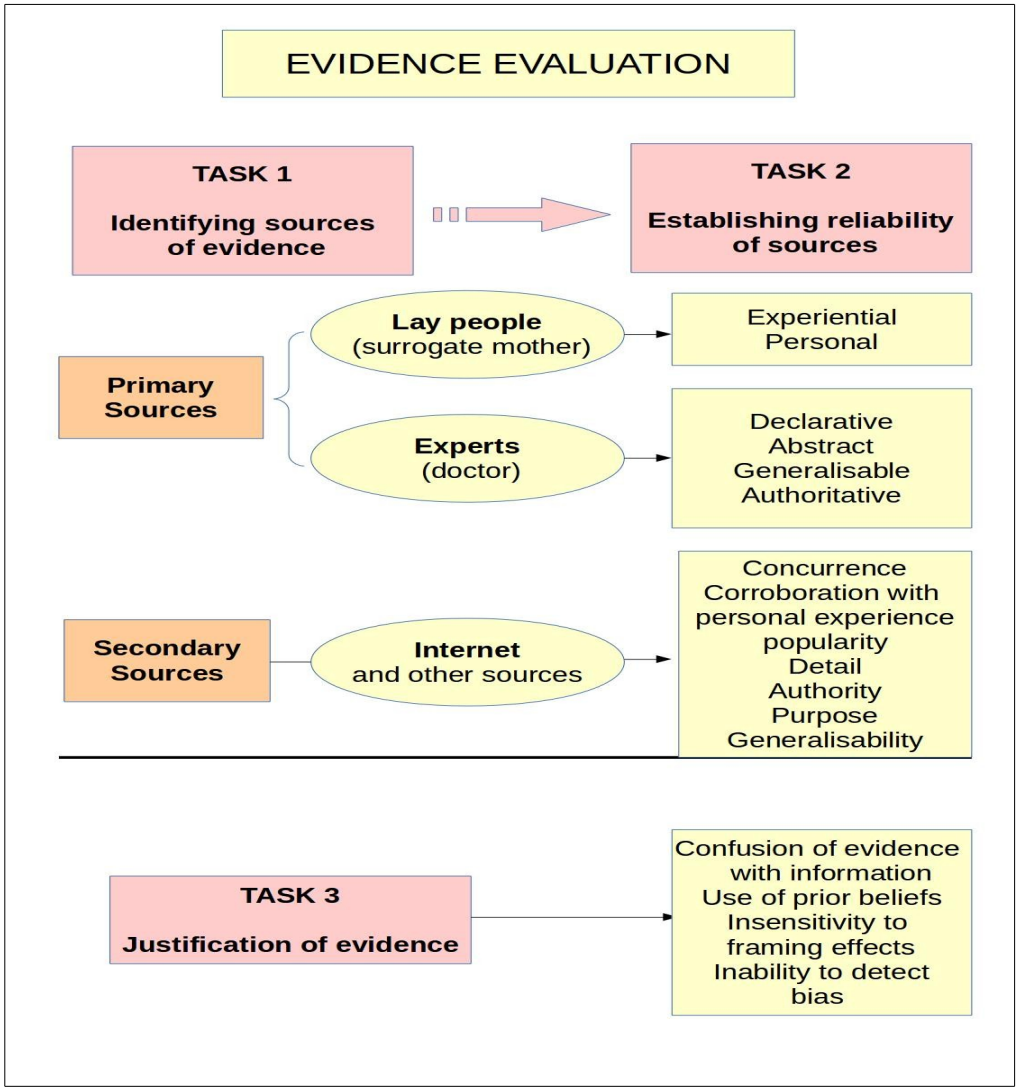

Figure 5.4 Criteria raised by students when evaluating sources of evidence

A POST SCRIPT TO CHAPTERS 4 AND 5

Reflections

Chapters 4 and 5 present findings from studies that investigated students negotiation of commercial surrogacy, a socioscientific issue related to IVF. While chapter 4 lays out the ethico-political and epistemic concerns that students raised when they first encountered the issue, chapter 5 delves a little deeper into the ways in which students evaluate complex evidence related to the health risks posed by the technology.

Levinson (2013) in an incisive critique of existing SSI research, notes that it is largely restricted to the western world, with very little reported from the developing world, particularly South Asia. He writes:

> ...one of the most populous regions in the world with a significant English-speaking population and more than their fair share of SSIs is south Asia, particularly India. One need only think of Bhopal. There are many environmental organisations, active scientists and interest groups who are dealing with scientific issues in India and other countries at similar levels of economic development. Why are there so few contributions to the SSI discourse from these areas of the world? Are we at risk of becoming too parochial?

Though researchers have begun pointing to this lacuna (Yahaya, Zain & Karpudewan, 2012), this study, perhaps is one of a kind that has looked closely at the nature of SSIs in the context of the developing world. More importantly, it acknowledges the political nature of these controversies, pointing to the unequal nature of the power relations between stakeholders involved in the controversy. In case of commercial surrogacy, for instance, it is important to acknowledge the existence of larger structural issues such as poverty impinging on the choices made by the surrogate mother, and that risk assessment of IVF will need to include her experiences of the procedure.

The analysis undertaken of students' negotiation of commercial surrogacy pays careful

attention to students' perceptions of social justice and views ethical decision making as occurring within a larger sociopolitical context. Say, for instance, when arguing that a woman is exercising her “choice” when opting to become a surrogate mother, students appeared to apply the concept of autonomy simply as an ethical concept, glossing over the fact that the decision is made under the compulsion of poverty. Likewise, simplistically applying the concept of justice and arguing for the accessibility of IVF through the public heath system makes no sense unless infertility as a health burden is weighed vis-a-vis other life threatening diseases. Students also appeared to struggle with the concept of poverty when arguing that IVF is advantageous because it improves the economic status of surrogate mothers. Besides these, positions that reflect patriarchial and casteist beliefs and prejudices also emerged in the context of discussion of the desirability of biological families versus social families and in the discussions around the social acceptability of surrogacy as a profession for poor women. These positions have been duly flagged and discussed.

Similarly, in chapter 5, explicit attention was paid to how students evaluate the status of expert versus lay knowledge, as also their understanding of the ways in which vested interests playing a role in how evidence gets presented. Whether they can differentiate an evidence based claim from one that is not was also investigated. Findings indicate that students were lacking in skills to engage with these aspects. That said, even if students develop an understanding of the complex nature of evidence around health risks, they will need to apply other values to the evaluation of whether a risk is acceptable or not. For instance, how does one decide whether a risk is “minor” or not and even if one decides this to be the case, would a surrogate mother be able to understand the nature of this risk to make a decision on her own? The challenges involved in helping students navigate these considerations are immense.

Limitations

It is also important to submit herein that the reported studies are exploratory and suffer from several limitations. I have only laid out the considerations that students raised when engaging with the SSI. The rhetorical strategies employed when carrying out the arguments have not been examined rigorously. Further research could examine these aspects more closely. One area of inquiry could be the ways in which science and religion are invoked when students

challenge each other. Akin to Nielsen's (2012 a,b) study, research could examine students' invocation of science and religion while engaged in argumentation. This will in turn provide specific insights to teachers on how students argue with each other and will help intervention.

An analysis of gender specific responses to the issue has also not been undertaken, as the sample was not sufficient enough. That said, it also did not appear from the data that there were any striking gender related patterns. I am more inclined towards looking at gender as socialization, though I do concede that the sex that is assigned to an individual at birth does play a role in how that individual is socialized to think and act.

When conducting individual interviews, an attempt was made to make sense of whether and how students construe the unequal nature of power relations that constitute the relationship between surrogate mother and the biological parents (see Appendix V, Part 2). This is discussed in the section on “autonomy and choice” in chapter 4. As I pointed out, conducting this discussion proved tricky and merits further exploration. Future work could build on this thread and examine more specifically how students integrate science, evidence and values when engaging in issues that specifically raise questions on social justice and violation of rights. Studies of this kind are specifically important to conduct in the context of developing countries where science and technology are often complicit in enforcing structural inequalities that are an outcome of capitalism, caste and gender.

In a criticism of existing classroom studies on socioscientific issues, Levinson (2013) notes, “If you want the students to study something which is of intrinsic interest to promote debate for citizens in a democratic society, then you need to pay attention to the students’ choice, however risky that might be” (p.112). He further points to activist-based studies that have overcome these problems, where students and teachers together tackle problems in the context of social action in their communities (e.g. Roth & Lee, 2004). The same limitation also applies to the studies that are reported here, in that the issue used was classroom based and can perhaps be treated as decontextualized as it does not lead to any immediate action in the real world.

That said, I am not entirely sure whether so-called action in the real world can solely be restricted to social action within communities. How, for instance, do we understand

engagement with socioscientific issues in the social media? These spaces tend to be highly interactive and often discussions and campaigns on facebook or twitter lead to action in the real world. In India too, discussion and deliberation on political issues happen on social media, though arguably its employment for activism has been largely restricted to the urban, middle classes (Chattopadyay, 2011). The nature of social media is such that users are pulled into discussions on issues that may be remotely related to them. Thus, we may need to expand our notions of what deliberation and action mean and begin to consider contexts where the lines between the two blur.

CHAPTER 6

CRITICAL SCIENCE EDUCATION BEYOND SCHOOL LEVEL

6.1 Overview of the chapter

While up till now, the focus of the thesis has been on critical science education at the higher secondary level, which represents the entry point to a specialized education in science, the following chapter attempts to conceptualize critical science education at a more advanced level. In a metalogue on SSIs in undergraduate education (Eastwood, Sadler & Jimenez-Aleixandre, 2011), Jennifer Eastwood points out that although articulations of bringing in ethical, social and political concerns into science education exists in higher education, the SSI terminology remains restricted to the science education community whose work by and large centers around school education. “Interdisciplinary education” has become the buzzword in college education circles and shares overlapping concerns with the SSI community, but has not drawn insights from the latter. In India too, articulations for interdisciplinary education exist in higher education. I review these in this chapter. I then employ the example of genetic determinism and in brief discuss salient findings from an exploratory study with doctoral students (Raveendran & Chunawala, 2015) that examined their views on genetic determinism. The discussion on genetic determinism serves as a useful point of departure to conceptualize what critical science education in higher education ought to be concerned about. Finally I turn back to a discussion of existing models of critical science education in higher education, their drawbacks and possibilities.

6.2 The changing nature and organization of science

Reality is complex and there is growing realization that reductionist methods of natural science are inept at providing a complete explanation of it. Scholars have begun to advocate the need to develop new methodologies which are more reflexive, open and involve dialogue between different modes of knowing, that will better help gauge this complex reality. Besides,

the organization of science has also undergone shifts with the site of production of knowledge no longer being restricted to the traditional university, but also other sites such as “consultancies, industrial, academic and government research laboratories, think tanks, institutions of national importance, hybrid research institutes across research institutes and industrial laboratories, and [...] the new social movements” (Raina, Pattanayak and valte, 2009, p.6). As a result, there has also been a concomitant shift in the nature of knowledge, from disciplinary knowledge produced within the laboratory and applied to the world outside, to transdisciplinary knowledge. In the words of Colucci-Gray, Perazzone, Dodman and Camino (2013),

> Transdisciplinary knowledge acquires its distinctive features from the nature of the problem that is being investigated, moving from the strict realm of application to the agora of public debate whereby a multiplicity of stakeholders is involved in formulating a problem and contributing heterogeneous skills and expertise (p.136).

During the 1950's and 60's, which constitute the first two decades post-independence, when India was reeling under severe setbacks created by colonial rule; the State focused on nation building by promoting 'scientific temper', through investment in science and technology. A ramification of this excessive faith in the scientific establishment was its protection from public audit of any kind (Nandy, 1989). Through the 70s to the 90s, public discontent towards science began to mount, which was in turn spurred by the environment movement as well as the failure of big development projects like the green revolution. However, the state continues to protect the technoscientific complex from social audit (Varughese, 2012).

Post liberalization, since the 1990s, scientific research has become increasingly privatized. Scoones (2006), commenting on the organization of science in India, writes:

> The enterprise of science and its relationship to policy and politics have changed [...] We are in an era when science and technology is not so much about big, state promoted state (sponsored) programmes led by 'big men' of stature and importance. Today the cutting edge of science and technology developments is all about interdisciplinary connections (p.55).

Further, Chattopadhyay (2014) points out that “if we look at the discipline-wise composition of science funding […], space and atomic research continue to be largely funded by the state, whereas private funding has witnessed a rapid rise in biomedical research where the potential for commercial exploitation abounds”.

Increased privatization of research has impacted scientific research of the developing world. Shrum and Shenhav (1995) point out that 98% of the R&D expenditure is on problems that affect the western world. Other changes include the move from basic to applied research and “increase in commercial confidentiality” as manifested in the Intellectual Property Rights regimes (Carter, 2008). Rajan (2006) notes that this shift is significant in the biological sciences where contexts of research have become corporatized.

This being so, the new science and technosciences, that have stepped out of the laboratory, and are being produced closer to the context of application (Carter, 2008), may no longer be guarded by the Mertonian norms of communism, disinterestedness and organized skepticism: Scientific knowledge is no longer publicly owned, produced in the interests of the public or subject to objective peer review. Thus, notions of accountability are also shifting in the changing socio-political climate within which science is done.

In the present scenario, if we need to reclaim the ideals of socially responsible and environmentally just science, we need reflexive and sensitive scientists who are willing to engage with the public on matters of concern that emerge from developments within science and technology and impact society. Science education will also need to take this challenge head on.

What does it mean to practice socially just science? Harding's (1991) formulation of what constitutes doing science directed by liberatory political goals is instructive :

> On scientific grounds, as well as for moral and political reasons, those social sciences that are most deeply critical and most comprehensively context-seeking can provide the best models for all scientific inquiry…the model for good science should be research programs explicitly directed by liberatory political goals….better science is likely to result if all the causes of scientific conclusions are thought to be equally reasonable objects of scientific analysis. (p.98)

Here, she makes an important point that reflexivity of a certain kind that asks questions on the purposes of scientific research, and is conscious of the larger social political context within which science is done will result in better science. Such an understanding is also beginning to find room in some higher education initiatives in India.

6.3 Critical science education: Articulations in higher education

Dhar (2011), in a discussion of the history of higher education policy in the country, points out that the Report of the University Education Commission (1948-49) emphasizes a tripartite division of disciplines on the basis of whether they deal with facts (Natural Sciences), events (Social Sciences) or values (Humanities) and this compartmentalization continues to rule the understanding of higher education in the country to this day. The report of the committee to advise on renovation and rejuvenation of higher education (Pal, 2009) also mentions "cubicalization" of disciplines as being one of the major problems plaguing higher education in the country, calling for making disciplinary boundaries porous and for science to concern itself with problems of the real world. Dhar, Siddiqui, & Chandrasekhar (2011) propose that these priorities need to be operationalized through courses at the undergraduate level that attempt "integration" across natural and human science disciplines. Such courses would help natural science students move beyond *awareness* of social and human issues to an *understanding* of these disciplines. Based on a survey of leading natural scientists and scholars in the humanities and social sciences in India, they list several ways of how integration has been understood :

(i) Reality being complex, the natural science methodologies need to be supplemented with other ways of knowing to better engage with it.

(ii) There exists a need to move beyond presumed binaries that divide the natural and human sciences – fact/value, sensory-experience / lived-experience, objective / subjective, universal / contextual, explanation / interpretation.

(iii) A well rounded scientist ought to be able to question the foundations of one's discipline as well as be familiar with other disciplines; in particular, the history, philosophy and sociology of science.

(iv) Science education should be made more relevant by incorporating components that discuss Indian contributions to science and technology.

(v) Courses in humanities and social sciences brings in sensitivity and commitment to social concerns in natural science students. This is because the nature of science is experimental and reductionist, thereby blinding them to larger concerns that affect the country as well as social and ethical concerns.

(vi) Scientists often play administrative roles. They therefore need to understand concerns related to development and globalization.

(vii) Scientists need to understand how globalization and the larger social and economic context impact the science that they do. Consequently, the need to expose students of natural sciences to courses that help them better understand these impacts.

(viii) Many scientific and technological products have an element of risk associated with them which scientists need to be aware of, as well as evaluate their products from the perspectives of the users/consumers / patients.

(ix) New methodologies to examine reality need to be created, which should be a result of the "interruption" of natural science with human science methodologies.

Dhar et al. (2011) advocate point (ix), the creation of new methodologies and new knowledges which would involve dialogue between natural and human sciences, that would be problem- inspired, not discipline-inspired, wherein the focus would be on solving the problem as is the case with transdisciplinary approaches.

In India, the need to introduce natural science students to courses in humanities and social sciences has been recognized to varying degrees and a few universities and elite institutes of learning like the Indian Institute of Technologies (IITs) have implemented courses at the undergraduate level. These have been reviewed by Raina, Pattanayak, & Valte (2009). They point out that while several universities such as Delhi University, IGNOU, Amritsar University, Hyderabad Central University and Pondicherry University have initiated courses in history, philosophy and sociology of science, these have have run up against difficulties, despite the enthusiasm with which they were initiated. Raina (2015) also draws attention to

the fact that increasing vocationalization and technification of universities has lead to devaluing of the social sciences and humanities as legitimate and important areas of study. Further, universities have withdrawn from the role of shaping social justice movements and imparting critical consciousness in the young. Courses in history, philosophy and sociology of science and technology offered at the elite institutes of science and technology in the departments of humanities and social sciences have sustained better, though students have limited interest in these courses. At the postgraduate and doctoral level, students have even lesser opportunities to opt for these courses, as the emphasis at this stage tends to be on specialization.

To facilitate integration, Dhar et al. (2011) suggest two models of integration in science education institutes: the soft model and the strong model. The soft model of integration involves exposing students to courses in humanities and social sciences alongside the courses in natural sciences in a way that they understand and appreciate the foundations of these disciplines. On the other hand the strong programme involves getting the disciplines to dialogue in a manner that would lead to a synthesis of new methodologies. To this end, they advocate teaching and research along integrated themes such as cognition, biodiversity, environmental science, biotechnology and bioethics.

The strong model, though worth considering does not appear be practical in the short run, given the orthodox mindset of the academia within the sciences. What might be practical, given the circumstances might be to reform the extant soft model of integration: instead of introducing students to history, philosophy and sociology of science courses in an add-on or decontextualized manner, they could be provided with actual examples within their areas of inquiry that call into question taken for granted positivist ideals of purity of scientific method and its ability to yield inherent truths about reality. There are numerous historical as well as contemporary case studies in the sciences that can be employed to get students to examine foundational assumptions that go into the construction of scientific claims (Allchin, 2011).

Genetic determinism is one such area that affords scope to be examined from philosophical, ethical and socio-political perspectives. As Timothy Barko ((Barko, Simon, Jimenez-Aleixandre & Sadler, 2011) remarks on employing a socioscientific perspective to gene expression:

> The SSI perspective begins to look at how gene expression has intersected with social and political ideologies. We begin to see what influence this intersection has on how we view our own potential, whether we see ourselves as plastic and free or fatalistic and determined. Different environments can lead to different gene expressions from the same DNA sequences. (p. 241)

A topic within the area of genetic determinism is neurogenetic determinism which establishes links between single gene mutations and complex human behaviors. Human behavior is an area that fascinates most people; and the media is rife with sensational articles reporting claims that posit the discovery of single gene causes of complex human behaviors like happiness, creativity and violence. In the next section, I illustrate the fallacious nature of these claims and briefly report findings from a study (Raveendran & Chunawala, 2015) that explored students' critical examination of the foundational epistemic assumptions that constitute these claims and the social and political aspects pertaining to them. The study affords a useful starting point to think about what a critical, contextualized biology education would look like.

6.4 Genetic determinism

Genetic determinism refers to the belief system that attributes substantial weight to genes in shaping human traits (Condit, 2007; Lewontin, Rose & Kamin, 1984). This is closely associated with genetic reductionism; the belief that, by understanding human beings at the level of genes or molecules, we can understand what it means to be human. Since the advent of the Human Genome Project, a spate of projects has focused on genetic causes of phenotypes ranging from disease conditions to states of the mind like happiness, which have been spurred by the development of new techniques to study DNA (Berkowitz, 1996). This framework has been criticized for being conceptually flawed. Furthermore, the socio-political ramifications of accepting deterministic claims have been debated widely in philosophical and scientific circles.

Deterministic claims in the area of neurogenetics are over-represented in science news (Bubella & Caufield, 2004). Who constructs these claims? Is it the scientist or the journalist? Although it has been pointed out that the media may have a role in sensationalizing and

misrepresenting human genetics research (Geller, Bernhardt & Holtzman, 2002), some studies (e.g. Bubela & Caufield, 2004) indicate that there is not much disparity between media articles and the scientific studies they report. This points to the possibility that science journalists and the scientific community may be "complicit collaborators" (Ransohoff & Ransohoff, 2000) in constructing such claims. Scientists, therefore, have a social responsibility to realistically communicate their research findings to journalists (Condit, 2007). In the following sections I summarize the epistemological problems underlying neurogenetic determinism as discussed by Rose (1995), the insights from recent research in neurobiology and developmental biology that challenge deterministic models, and ethical issues raised by genetic determinism as a philosophy.

6.4.1 Criticism of neurogenetic determinism

In a 'Nature' article titled, "The rise of neurogenetic determinism", Rose (1995) discusses the epistemic assumptions underlying the faulty sequence of reductive steps employed in constructing reductionist claims in neurogenetics. These include reification, arbitrary agglomeration, improper quantification, belief in statistical normality, spurious localization, misplaced causality, and dichotomous partitioning between genetic and environmental causes.

Reification "converts a dynamic process into a static phenomenon" leading to a loss of meaning. Therefore a phenomenon like violence, which is complex and contingent on social context for definition, is isolated and abstracted into a trait like "aggression" that becomes perceived as universal and objectively definable. Once reified, a range of behaviors not related to each other are treated as exemplars of the same trait ─ a step in the neuroreductive sequence known as arbitrary agglomeration. Rose illustrates this step with an example of how the term "aggression" is used to describe a range of behaviors that may not be related to each other ─ a man abusing his wife, fights between football fans, racist or sexist attacks, and wars.

The next step, improper quantification – gives the reified and agglomerated characters a numerical value, enabling comparison of two individuals on the basis of such traits. In animal studies, for example, a behavior such as the time taken to kill another animal is measured to quantify aggression and then extrapolated to human behavior. Belief in statistical normality presupposes that the distributions of such behavioral "scores" are normal. This is followed by

spurious localization where the reified character “ceases to be a property even of the individual but instead becomes that of a part of the person” (p. 381) – as is evident in ideas like schizophrenic “brains” or “genes”. Once a phenomenon gets reified, agglomerated, improperly quantified, and spuriously localized into a trait, it becomes possible to erroneously correlate levels of a biomarker or a mutation in a gene with the so-called trait or phenotype. This is misplaced causality, the next step in the neuroreductive sequence. In many cases there are environmental causes that lead to the development of the phenotype. However neurogeneticists downplay these causes and referring to them as phenocopies (Berkowitz, 1996).

6.4.2 Criticism of genetic determinism: Insights from within the discipline

Deterministic claims can be criticized not just on the basis of epistemic or foundational assumptions, but also on the basis of more “domain specific” research findings – such as recent research in the fields of neurobiology and developmental biology which has brought forth explanations on the relationship between the genotype and the phenotype that challenge the linear, deterministic model. For every gene, there is a complex and intricate network of regulatory pathways that determine how much protein it produces and at what time. Segments of DNA that are located both near and far away from the gene regulate its activity, which are in turn regulated by proteins produced by other genes, RNA molecules or dietary substances. These findings emphasize that the unit of analysis should not be a single gene but a network of interactions. Therefore, emergent properties in a network, which may not be obvious if we study only a single gene, need to be taken into account when explaining the genotype-phenotype (G-P) relationship (Berkowitz, 1996). In this regard, Pigliucci (2010) suggests a more complex, interactionist framework of developmental encoding to explain the G-P relationship – one that foregrounds the role of developmental mechanisms in effecting the phenotype. According to such a framework, genes would only be one among several causal factors that influence the development of the phenotype. He cites literature that discusses how the amount of genetic information present is too limited to specify the “spatial location, functionality and connectivity” (p. 562) of the human brain and therefore cannot be solely responsible for coding the phenotype. This problem is circumvented by the “local deployment of information that is possible through developmental processes, where the genetic

"instructions" can be used in a way that is sensitive (and therefore capable of adjusting) to both the internal and external environments" (p. 562). Developmental mechanisms both affect and are affected by gene expression. These events are in turn closely regulated by environmental cues (Lewontin, 2001).

Some studies have been carried out with a view to understanding how learners grapple with disciplinary knowledge on the G-P relationship. Duncan & Reiser (2007) identify three main obstacles to their understanding of this concept. The first pertains to the fact that genetic phenomena are invisible and hence not easy to conceptualize. The second arises from the complicated organization of genetic phenomena – the multiplicity of levels that involves genes, proteins, cells, tissues and organs. Understanding genetic phenomena therefore includes understanding how entities at lower levels interact and bring about changes at higher levels. Some studies have pointed out that students have difficulty reasoning across multiple organization levels (Duncan, 2007; Duncan & Reiser, 2007; Marbach-Ad & Stavy, 2000). The third reason learners struggle to understand the G-P relationship is because genetic phenomena are brought about by interactions between informational entities (genes) and biophysical entities (proteins, cells and tissues) which are ontologically different. In their study of tenth graders, Duncan & Reiser (2007) found that the students faced conceptual obstacles while making sense of these interactions. These students also faced difficulties in understanding the role of proteins and their mechanism of action in effecting the phenotype.

6.4.3 Ethical issues surrounding genetic determinism

Apart from the conceptual issues delineated above, there is also the fact that deterministic claims on behavior are interpreted in a socio-political context and could therefore raise ethical concerns. "Conditions" like homelessness or violence among the poor, which have an obvious social basis and are remediable through social intervention or policy change may get attributed to faulty genes. This may lead to victim blaming or diversion of resources from studies on important environmental and cultural determinants of a trait (Räisänen, Bekkers, Boddington, Sarangi, & Clarke 2006). Another concern is the fear of facilitating the "back door entry" of eugenics (Singh & Rose, 2009). The much-touted discovery of a "gene for a trait" could facilitate risk-profiling of individuals, which in turn could be used to stigmatize

them. Victims may also develop a fatalistic sense that they are genetically doomed to carry certain genes and the associated “traits” are immutable (Rose, 1995; Joseph, 2000).

Kitcher (2003), in his discussion on political asymmetry, writes,“Standards of evidence must go up when the consequences of being wrong are more serious” (p. 97). In other words, if a certain scientific theory or claim implies support for anti-egalitarian conclusions, the evidence for the former must be strong. Deterministic claims related to behavior, cognitive capabilities and personality could potentially be used to stigmatize already marginalized groups. As per Kitcher’s argument, if scientists engage in such research, they would need to apply rigorous standards of empirical adequacy in their work. Hence, there is reason to believe that ethical sensitivity is a necessary quality in a good scientist and an education in ethics needs to be part of science education.

6.5 Student's evaluation of genetic determinism

A few studies have looked at the problem of genetic determinism and students' understanding of epistemic and ethical dimensions of these claims. The work of Jiménez-Aleixandre & Puig[28] (2011) is notable in this area. They used the context of performance in athletics to explore how students negotiate the problem of biological determinism. In their analysis, they used a framework of critical thinking that combined evidence evaluation and social emancipation components. Along these lines, we undertook a study of how doctoral students examined a deterministic research claim in neurogenetics. The study[29] involved 30 students conducting research in biological sciences in six premiere research institutes of India. Students read a media article that reported a correlation between a genetic mutation and creativity. They then responded to a series of questions on the article.

28 Other published work on the same topic include Puig & Jiménez-Aleixandre (2011), Jiménez-Aleixandre (2014), Jiménez-Aleixandre & Puig (2012).

29 A more detailed discussion of results can be found in Raveendran & Chunawala (2015). In this thesis, I only present salient findings of the study to build a case for critical, contextualized science education.

6.5.1 Description of the media article

The media article reported a study, originally published in the *New Scientist*[30], claiming that a genetic mutation responsible for schizophrenia (neuregulin) also controls creativity. Creative individuals, ascertained through certain criteria like filing a patent or writing a book and creativity tests, were genotyped for the presence of the mutation. It was concluded that people who had two copies of the mutation were on an average more creative than people who had one copy of the mutation, and those with a single copy were more creative than ones with no copy of the mutation. The article reported the lead scientist of the research team (Keri) to have cautioned that the results do not entail that psychosis and creativity are the same. He speculates that it is IQ that probably determines whether a person develops schizophrenia or creativity, as clinical experience has revealed to him that high IQ people are better able to deal with psychotic delusions.

The article was emailed to the students along with a series of questions that invited them to critique the article in terms of epistemic aspects (Q. 2) as well as in terms of its utility and consequences (Q. 3 and Q.4) :

1. Summarize the key findings of the study.

2. Can a conclusive link be established between neuregulin mutation and creativity? If yes, how? And if no, why not? Please elaborate.

3. What are the implications of the study?

4. An Indian group wishes to replicate Keri's study in India. Do you think this study should receive funding? If yes, why and if no, why not? Please elaborate.

Students employed a wide range of criteria when evaluating the deterministic research claim. These have been categorized into two broad categories – those motivated by Epistemic and Ultimate values. Epistemic values motivate evaluation of the research study in terms of logical and methodological parameters as well as disciplinary knowledge. Ultimate values,

30 Link to the New Scientist article: http://www.newscientist.com/article/dn17474-artistic-tendencies-linked-to-schizophrenia-gene.html (A re-reported version of the above article by Asian News International was presented to the students)

introduced by Allchin (1999), describe values that motivate evaluation of the study in terms of utility and consequences – choice of topics of research as well as decisions regarding their ultimate purposes. For instance, extending knowledge of the natural world or developing weapons technology are value-laden goals. Figure 6.1 summarizes the epistemic and ultimate criteria raised by the students.

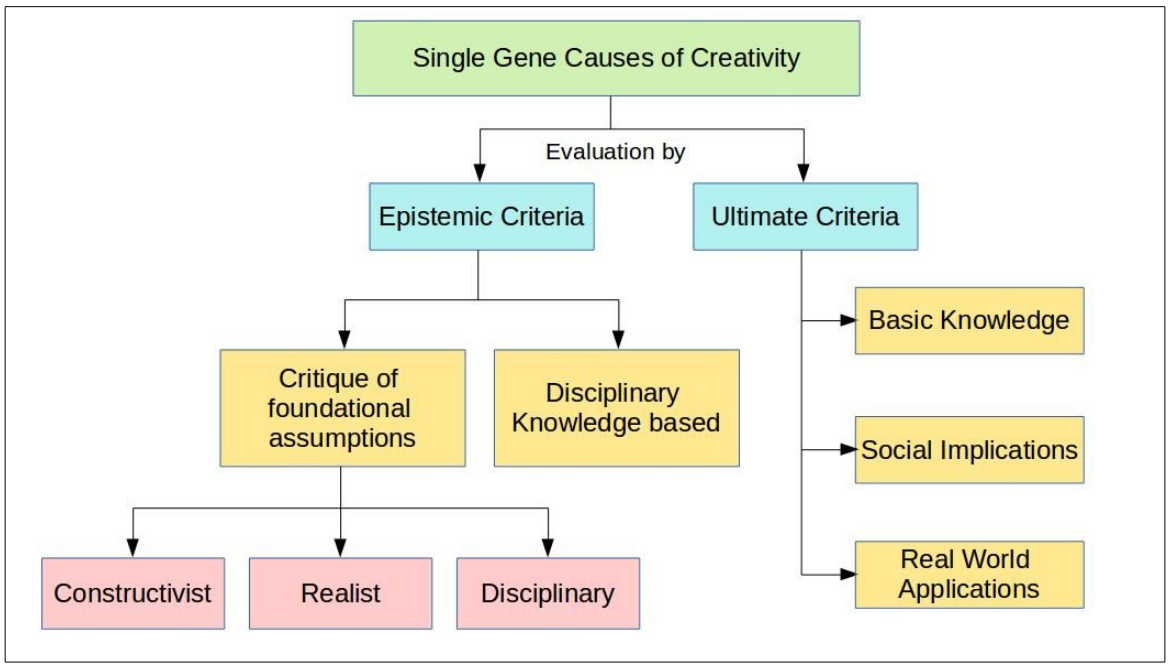

Figure 6.1 Epistemic and Ultimate Criteria generated by students

6.5.2 Criteria motivated by epistemic values

Students generally raised epistemic criteria when responding to question 2. These criteria broadly fall into two categories: Those that deliberated on the foundational assumptions constituting the claim and those that invoked disciplinary knowledge.

Deliberating on the foundational assumptions underpinning the deterministic research claims is an important philosophical exercise. Students who raised basic questions on the nature of creativity, whether it can be defined and measured, or discussed the role of other variables (other than genetics) that influence creativity indicated an orientation that tries to understand foundational assumptions that constitute the claim. Although a majority of the students did

this, their responses divulged varying levels of sophistication.

For instance, students whom we characterized as exhibiting a *constructivist* understanding of the phenomena (understanding creativity as a construct) understood the problem of reification. This is further demonstrated by their strong skepticism of measuring creativity. Students who indicated a non-constructivist or *realist* understanding of the phenomena, on the other hand, pointed out the difficulty in measuring creativity but did not deliberate on the eventual possibility of doing so. The difference in the epistemological positions of students who exhibited a constructivist understanding of creativity and others is an important one - the former were highly skeptical of the assumptions of the study, dismissive about its implications and raised questions on whether the study merited funding. The remaining one-third of the students adopted a discipline-based approach in their analysis and did not critique the foundational assumptions of the study of the claim. What motivated this approach needs further investigation. Table 6.1 provides examples of some of the epistemic criteria raised by the students.

Apropos of criteria that were based on disciplinary knowledge, which most participants raised in their analysis, we find theoretical knowledge of the Genotype-Phenotype (G-P) relationship wanting in most students. In the responses, most references to theory were sketchy and involved elementary knowledge of genetics. Students did not display awareness of the interactionist, developmental coding perspective on genotype to phenotype mapping and of the complex relationship between genes, developmental mechanisms and the environment.

In summary, although most of our sample attempted to critique genetic determinism in terms of the epistemological basis of these claims, their command in doing so varied greatly. With regard to their use of disciplinary knowledge, theoretical knowledge on the G-P relationship appeared wanting.

Table 6.1 Epistemic criteria raised by students

I. Nature of creativity (N=19)	Pointed out the complexity of the trait, difficulty in measurement. Were skeptical of defining creativity, some pointed out the socially constructed nature of creativity
Constructivist understanding of creativity (6/19)	Creativity is viewed as a construct contingent on operational definitions. *"Creativity is a subjective trait and it could lead to inaccurate estimates...there is a bias in how you define and measure creativity...how could you classify a person as 'uncreative'?"* (P_{12})
Realist understanding of creativity (13/19)	Did not question the existence of the trait per se, but pointed towards difficulty in defining and measuring it. *"Creativity is a word that covers a broad range of abilities from writing to dance; from singing to painting. The study should have looked at artistes and writers to see if the mutations were indeed seen in individuals from different streams of art"* (P_5).
II. Other variables in the environment that could play a role in creativity (N=8)	Role of factors in the environment (age, gender, nutritional status etc) *"The only measured variables were their 'creativity scores' and whether they carried the neuregulin mutation. What about their backgrounds? Did any of these volunteers have parents who were artists?"*(P_{15})
Disciplinary approach: (N=11)	Did not raise foundational questions on the nature or existence of creativity, but approached it from a purely disciplinary point of view *"For conclusive evidence, the first requirement would be to eliminate effects of 'genetic background' following which further studies to elucidate a proper mechanism, and circuit based pathways would be necessary to potentially implicate neurogulin is linked to creativity."* P_4

6.5.3 Criteria motivated by ultimate values

Generating ultimate criteria, in terms of implications and funding when evaluating any scientific study is not an easy task and calls upon the careful consideration of many factors. Questions 3 and 4 were aimed at eliciting these criteria. More than half the students believed that the study merited funding. A considerable number of these students valued the study for its role in furthering basic knowledge while others discussed social implications as well as applications (Table 6.2). These viewpoints among students are interesting and need further

examination.

Although students did evaluate the claim in terms of its social implications, very few students discussed sociobiological implications related to the claim. In our view of critical thinking, students who are critical thinkers ought to identify discourses that support inequality. Although it was indeed a redeeming fact that the few students who raised socio-biological implications discussed these in a negative light, the silence of the rest of the students on this matter is intriguing. As pointed out by Kitcher (2003), rigorous epistemic standards need to be applied when evaluating research that is liable to be used for politically regressive purposes. We believe that concerns regarding sociopolitical implications of their research should be part of scientists' consciousness as it can help them conduct socially just and epistemologically sound research.

Table 6.2 Ultimate criteria generated by students

Criteria	Example
Role in futhering basic knowledge (N=12) Responses focused on the importance of the study in contributing to the repertoire of basic knowledge in discipline.	*"...Most important implication is increase in the understanding of basic phenomena in the workings of brain and their link to behavioral aspects of humans. (This study) provides a starting point of looking at traits like creativity from a purely molecular and objective way"* (P_{20})
Social implications (N=10) Responses discussed social implications of the claim, either in terms of the negative sociobiological impications or more positively, in terms of removing stigma against mentally ill.	*What motivates scientific studies, is it merely curiosity? ….when I raised a debate on 'The search for the gay gene' i.e., a genetic basis to explain homosexuality in humans, I was told 'If you don't possess the curiosity to find biological proof for your sexual orientation, you are not a scientist' However, I am not sure if scientific studies are always bias free and thus solely curiosity driven*. (P_7) *"... On the brighter side, it could alter people's view of mental illness pushing them to appreciate its sophistications rather than look at it with predominantly negative and sympathetic mindset" (*P_{27})
Real world applications (N=6) Responses raised questions on practical applications of the research study, for example, drug designing.	*"Research should be oriented at more useful endeavors. There is no good application to this kind of research. If one intends to do pure science then it should at least not have harmful implications to society"* (P_1) *"...looking at the positive side, a psychotic patient can in fact be treated to become more creative"* (P_{19})

6.5.4 Implications of the study

There are several levels of philosophical questions that students can grapple with when they evaluate deterministic claims on complex behaviors or qualities like happiness and creativity. The following questions, for instance, have a basis in Longino's (2006) discussion of theoretical pluralism:

1. What is the nature of the behavioral trait that is being studied? If we accept that how we operationalize the definition of a trait is contingent on social and cultural context, can it still be measured?

2. If we accept that the trait can indeed be measured, then how do we define our causal space? What factors do we measure and what do we leave out?

3. What is the nature of knowledge that we have produced? (permanent and certain or partial and provisional?)

4. What are the social implications of the knowledge that we produce?

Discussion of these questions can lead to further explorations in philosophy of science, such as how true are scientific descriptions of the world, the social dimensions of scientific knowledge as well as sociopolitical implications of scientific claims. For teachers to be equipped to discuss such issues, they would need to be exposed to philosophical literature that discuss values in science as well as develop an understanding of how genetic determinism opens up questions on values and science. For instance, exposure to Longino's (1983, 1987) classical and accessible work, which illustrates how values mediate scientific inferences could be beneficial. Philip Kitcher's (2003) work that discusses the social responsibility of science also might afford insights into the question of what it means to pursue science with a commitment to democratic ideals.

Trends in our data raise questions about the cross-disciplinary knowledge possessed by students ─ that goes beyond knowledge of one's own discipline ─ to evaluate deterministic claims. If we take a look at the epistemic criteria that the students generated, we find that only one-fifth of our participants could articulate the problem of reification. Understanding that what is being investigated is an operational definition of creativity; a construct determined by

value-laden norms requires an approach that a narrow disciplinary training in biological sciences does not provide.

As our results indicate, only a few students raised concerns regarding the use of the discourse of genetic determinism to support non-egalitarian policies. Develaki (2008) discusses the various dilemmas surrounding socio-ethical dimensions of the natural sciences. One of the major moral dilemmas confronting natural sciences today is the tension between "legitimate right to research freedom" and the "freedom from socio-political intervention" on topics or ends of research. On the issue of social sensitivity of scientists, she argues that it is important for:

> the scientific community … to make known instances of dangerous research or the exploitation of scientific knowledge by certain groups, or to further awareness of the price society might have to pay for the risks that are present in technological solutions (p. 877).

She further argues that the knowledge needed to deliberate on such issues requires the synthesis of scientific as well as non-scientific perspectives that include disciplines like philosophy and sociology. Students with such cross-disciplinary perspectives would not only have a thorough knowledge of their own disciplines, but also grounding in other disciplines, so as to better engage with others' arguments. Our data evinces that students possessed limited cross-disciplinary knowledge. Cross-disciplinary perspectives may also contribute to the development of dispositions of criticality towards one's own community. Exposure to the self-reflexive, qualitative paradigms that are gaining ground in the social sciences and humanities, may help develop these dispositions (Dhar et al., 2011).

6.6 Contextualized science education

The example of genetic determinism affords a context to start articulating what critical science education at higher education levels ought to be concerned about. Future studies could identify similar topics and employ these as contexts to initiate students into thinking about the larger social, political concerns within which science is done, how these affect the kind of questions that get investigated as well as the role of these concerns in shaping theory construction. This would make for a critical, *contextualized* science education wherein, in

Shah's (2012) words,

> Scientific knowledge, like all other knowledges, is perceived as being embedded in its context, and the process of its production is seen as important for understanding it as the finished product. (p.166)

A skeptical response to the idea of contextualized science education might be that topics such as neurogenetic determinism represent cases of “bad” or “wrong” science, and that values cannot be brought into teaching topics, where such biases and prejudices are not obvious. My rebuttal is simply that these “extreme” cases help initiate students into thinking about the assumptions that go into theory construction.

Why do students need to examine the assumptions inherent in any scientific statement? An answer to this can be found in Longino's (2004) discussion on the need to expand the notion of justification inherent in mainstream philosophy of science:

> (Justification entails) not just … testing hypothesis against data, but also in subjecting hypothesis, data, reasoning, and background assumptions to criticism from a variety of perspectives. Establishing what the data are, what counts as acceptable reasoning, which assumptions are legitimate, and which are not become in this view a matter of social, discursive interactions as much as of interaction with the material world. Since assumptions are, by their nature, usually not explicit but taken-for-granted ways of thinking, the function of critical interaction is to make them visible, as well as to examine their metaphysical, empirical, and normative implications. (p.133)

She further elaborates that understanding cognitive practices as having social dimensions integral to them entails setting up norms by the community to ensure that critical interaction is made possible within the scientific community as well as with the public. On the question of the purposes of scientific activity, which she understands as truth-seeking, she writes:

> Which kinds of truths are sought in any particular research project is determined by the kinds of questions researchers are asking and the purposes for which they ask them, that is, the uses to which the answers will be put. Truth is not opposed

> to social values, indeed, it is a social value, but its regulatory function is directed/mediated by other social values operative in the research context. (p.135)

Thus, not only is "the social" an essential part of the epistemic practices that constitute scientific inquiry, the pursuit of truth, in and of itself, has to be understood as a social value. When the pursuit of truth is set apart as an asocial, transcendental value, the social becomes divorced from the scientific, thereby reducing the social responsibility of science to the evaluation of the applications of science by scientists. Understanding the core of scientific activity as permeated by social and political concerns, affords new ways of restructuring and reimagining the nature and goals of scientific inquiry.

6.7 What then of integrated science education?

At this juncture, I turn once again to the models of integrated science education proposed by Dhar et. al (2011) discussed at an earlier point in this chapter: the soft model and the strong model. As mentioned, the extant structure of integration in colleges and universities is the soft model which is largely enacted in a didactic manner wherein students of science are taught history and philosophy of science in addition to core content-oriented courses. A slightly improved version of the soft model would be something akin to critical contextualized science education discussed in the previous section. There are, however, limitations to the contextualized approach, as there are only a few topics where the context is actually visible and these largely tend to be concentrated in the biological sciences. Second, teaching through a contextualized approach will require extensive preparation on the part of teachers (Allchin, 2013) and if the curricular pressures continue to prioritize breadth over the depth of content, contextualized teaching might prove difficult.

The strong model of integration that advocates teaching and research of integrated themes would involve going against the grain. The aim is to move towards transdisciplinarity, where disciplinary approaches and methods are dictated by what the problem demands. An example is sustainability science, which involves a coalition of approaches from various domains. These include the natural sciences, humanities, the arts and indigenous knowledge systems and involve a wide variety of actors. Just as the problems are complex; methods employed are not set, and would in turn depend on how the problem is framed. Pedagogy and research

would have to occur simultaneously, where the teacher also is a learner along with the students. However, as indicated earlier, these approaches would require bold steps towards overhauling the existing system. Until then, perhaps contextualized approaches make more sense to implement.

CHAPTER 7

REFLECTIONS AND FUTURE DIRECTIONS

7.1 Overview of the thesis

What broad insights does this thesis afford? It charts out a vision for critical science education in India which places science in the sociopolitical context within which it is done. It does so by drawing together and emphasizing perspectives on science and technology that demonstrate its value-laden nature, pointing to limitations of the existing curriculum and illustrates ways in which this vision can be realized through the introduction of socioscientific issues at the higher secondary school level and beyond. Discourses on politicizing science education and transformative science education should find their way into higher education as much as school education, given our understanding of how the nature of science is impacted by the larger social political context within which it is done. Good science education[31] should, as Shah (2012) puts it, result in:

> … a more informed public that benefits from under-standing the nuances and complexities of science and a more sensitised scientific community that takes this discipline to newer depths while recognising the limits and possibilities of partial visions instead of supposedly enlightened certainties. (p.168)

Just as we need citizens who are empowered to use science for social justice, and critique science that is misappropriated for ends that are inimical to the ideals of social justice, we need scientists who are reflexive practitioners. This becomes challenging, particularly when disciplinary pressures start mounting in higher education.

The SSIs discussed in this thesis, as well as the discussion of students negotiation of these

31 The idea of “good” science education follows from Harding's (1991) definition of good science, “ the model for good science should be research programs explicitly directed by liberatory political goals”

issues provide solid contexts to begin conceptualizing critical science education at the respective educational levels. What underpins the empirical studies around SSIs reported in the thesis is the focus on students' understanding of epistemic, socio-political and ethical concerns. In both contexts (higher secondary and doctoral), issues related to the social and political impact of science and technology has been central to the ways in which I have construed and presented the dilemmas to students as well as evaluated their responses. In my work with higher secondary students, getting them to evaluate the technology from the perspective of surrogate mothers, as against a neutral detached viewpoint that would foreground the technology and how it works, helped in eliciting students' value positions on issues related to social justice and the ethical conundrums surrounding the technology. Similarly, in the study with doctoral students, there was a specific focus, in the analysis undertaken, on whether and how these students critiqued the foundational notions of genetic determinism as a philosophy, as well as the socio political implications of such claims.

Hodson (2011) characterizes the functions of critical science education in terms of conferring certain epistemic skills, sociopolitical commitments and dispositions (discussed in the Introduction). The findings from all the undertaken studies in this thesis have been discussed in terms of these aspects, excepting for the dispositional aspects. Chapters 2 and 3, which report an analysis of the class XII biology textbook and curriculum documents demonstrate a lack of careful attention being paid by the textbook writers to the values transmitted through the textbook, and the epistemic skills required to critically evaluate information, particularly the risks associated with technosciences. Chapters 4 and 5 evince that when negotiating a socioscientific issue, higher secondary biology students espoused value commitments that are inimical to the ideals of social justice. Skills required to critically evaluate evidence when assessing risks were lacking in many participants. In chapter 6, I make a case for critical science education in higher education reviewing extant initiatives in India. I further employ the example of genetic determinism to discuss contextualized, critical science education and critically evaluate the proposed models.

Thus, through the discussion of socioscientific issues that could be taken up for discussion at the entry point and advanced levels of a specialized education in science, I have attempted to lay down qualities needed by citizens and scientists alike to determine the course of science

and technology that are responsive to the needs of all members of society, upholding the ideals of social and environmental justice.

7.2 Applying critical theory to SSI research: Essential tensions

Socioscientific issues, being controversial in nature, always play out in an ideological terrain (Levinson, 2007). In a metalogue on applying critical theory to research in socioscientific issues (Barko et al., 2011), Troy Sadler raises an important concern: what if engaging with socioscientific issues leads students to develop conservative, non-emancipatory ways of thinking? Should SSI based instruction explicitly teach students to adopt emancipatory, progressive perspectives? and if this is the case, would it not amount to indoctrination, if we do not allow learners to develop their own perspectives on these issues? In response to this question, Timothy Barko remarks:

> ... In order to approach science (education) with a critical theory perspective we must assume science is “burdened” by politics, but in so doing, we must also acknowledge the inherent political assumptions of critical theory, that in doing science from a critical theory perspective we too are using science to support specific political agendas, that the finger too, can be pointed back at us. (p.240)

What follows from Barko's argument is that if we assume that science or science education is necessarily burdened with politics, then teaching these issues cannot be done in an apolitical manner. My stand is that teachers do need to make their positions explicit on these issues, if not at the outset. On the issue of whether students ought to be explicitly taught to adopt emancipatory positions, my position is that they should be, because positions that uphold prejudices or are contrary to constitutional values are not rationally defensible (Levinson, 2007). The challenge lies in developing constructivist pedagogies which would be dialogic as opposed to didactic in nature, which would illuminate to students why they need to develop values that are emancipatory.

7.3 Placement of SSIs in the curriculum

Socioscientific issues are part of the school curriculum in the United Kingdom, North America, Western Europe, Australia, Canada and a few Asian countries (Levinson, 2007,

Topcu, Mugaloglu & Guven, 2014). Even if socioscientific issues have not been introduced in the curriculum in many of the Asian countries, research on how students negotiate these issues are underway (Wu & Tsai, 2011, Yang & Anderson, 2003). As discussed, though the need to incorporate the relevance of science to society in the science curriculum has been argued for in the national curriculum documents in India, there is no mention of how to infuse it into the curriculum (particularly at the higher secondary level) leaving us with some questions: first, should socioscientific issues necessarily be a part of the science curriculum at the school level or should it be taught as a separate subject? Answering this takes us back to the goals of science education and what should be taught in the science classroom: A vision I perspective on scientific literacy would center the teaching of academic content and marginalize STSE concerns, while a vision II perspective, in its most polemical form, questions the academic science content that is discussed in textbooks. Most curriculum documents would acknowledge the twin goals of learning academic science as well as teaching "citizenship skills" to students. The problem with pairing these goals (of teaching academic science content and socioscientific issues) is that they do not sit comfortably together and very often, engaging with SSIs is not given priority. A case in point is the Salters' Advanced Level Chemistry course (post-16 level) in the United Kingdom which uses socioscientific contexts to teach scientific concepts. In an incisive critique of the course, Hughes (2000) points out that STS is marginalized in three ways:

> First, the language and structure of syllabus texts allow devaluation of socioscience with respect to abstract scientific principles. Second, socioscience is either omitted from the classroom and teaching practices or else appears only in peripheral activities. Finally, students' narrow interpretations of applications of science mean that they are not receptive to socioscientific discourse; they appear to be strongly influenced by the marginalization of social context in course documentation and classroom activities. (p.427)

As discussed, at higher education levels in India, STS courses are offered by various universities and institutes to undergraduate and post-graduate natural science students (reviewed by Raina et al., 2009). However, these have not sustained, arguably due to a lack of an overarching mandate regarding how STS education should be instituted at these levels. A

way forward would be to draw insights from programs like the integrated science education initiative (reviewed in chapter 6) that affords interesting models on how to expand student sensibilities to accommodate societal concerns and facilitate the production of new kinds of knowledge(s).

Thus, my response to the question of whether SSIs ought to be introduced through the academic science curriculum would be that to do so might prove futile, unless and until the existing science curriculum significantly revises its understanding of the nature of science. This would involve understanding that facts and values are enmeshed in complex ways. In my opinion, unless academic science is also conveyed in a manner that help students appreciate its social, political embeddedness, students may not fully appreciate the complex inter-linkages between science and society, tending to compartmentalize academic science content and STS, as lying within the domains of facts and values respectively. The same would apply in higher education as well. As discussed, implementing a “soft” model of integration would involve teaching history, philosophy and sociology of science in an add-on manner, which would not radically challenge the fact/value dichotomy. A strong model, on the other hand, would prescribe teaching integrated themes that would facilitate dialogue across different ways of knowing, in turn breaking down the fact/value dichotomy. Implementing a strong model would require time, resources and challenging the rigid divisions between disciplines extant in academia.

Given the existing situation, on a more pragmatic note, I would concede that SSIs do need to be introduced in the curriculum, if not through the science syllabus. Irrespective of where these are placed in the curriculum, the pedagogical challenges of transacting these issues would remain. In the next section, I set forth these challenges.

7.4 Pedagogical challenges in transacting SSIs

What skills and knowledge would teachers require when helping students negotiate socioscientific issues in the classroom? Existing research points to several factors that deter teachers from doing full justice when introducing SSIs. These factors involve lack of confidence in dealing with the controversial dimensions inherent in these issues which in turn stems from an inadequate knowledge of the nature of scientific, political and ethical

dimensions embedded in these issues (Levinson &Turner, 2001; Reis & Galvão, 2009), as well as loss of control in classroom contexts (Stradling, 1984) as the nature of discussions around these issues entails challenging teacher authority (Levinson, 2007).

The nature of SSIs are such that their negotiation requires the integration of different areas of knowledge, thereby raising the question of science teachers' preparedness to deal with the complex nature of moral and political questions that these issues pose. As Levinson (2007) posits:

> ...a rigid dislocation between scientific knowledge, evidence and ethics would seem to hinder a pedagogy dealing with controversial socio-scientific issues. If, however, these issues were dealt with wholly in science lessons the demands on the science teacher to do this and teach the content of the science curriculum would be too great; alternatively if taught solely in humanities lessons there is a danger of losing the effect of a topical science context. (p.192)

Levinson goes on to suggest that an integrated teaching approach involving science and humanities teachers may well work, but would require substantial amount of professional development. He also suggests that socioscientific issues be taught as an independent subject, such as critical thinking or citizenship education which would involve only one teacher. Further, he also draws together a set of “common practices” that teachers can adapt when discussing these issues:

- Helping students to understand that facts in socio-scientific issues are rarely socially neutral.
- Teaching the critical analysis of everyday sources of information such as newspapers, magazines and TV programmes.
- Judicious choice of role plays to appreciate diverse points of view on an issue.
- Demonstrating and modeling how different ethical principles can be drawn on in discussing an issue and that there is a relationship between the type of evidence selected and the ethical framework.
- Problematising interpretations in everyday meanings.

- Detailing conflicts of interests on both a local and global scale and communicating that resolution might be complex.
- Making available accounts of how experiences can validate judgments. Such experiences are common in the teacher's repertoire.
- Confidence and relationships regulate the kinds of experiences which can be openly discussed.
- A commitment to rationality in discussion such as clarity, truthfulness and self-consistency, which needs to be taught, modelled and rehearsed.
- An awareness that the teacher is in a position of power and that certain terms carry cultural weight which might sit oddly with students. (Levinson, 2007, quoted verbatim, p.164-165)

7.5 Future directions

Before I conclude, I offer a few directions for future research. My work has only been able to capture, in the form of snapshots, the kind of considerations students bring to bear on socioscientific issues when they first confront them. As Jones, McKim & Reiss (2010) note, an "individual's ethical position on a socioscientific issue will be affected by the individuals around them, the particular scientific or technological issue being considered, their motivation and a range of other factors" (p. 14). It would be worthwhile for future studies to carry out longer interactions with students and capture these aspects as well.

Studies that explore teaching of these issues are also very important from the point of view of teacher education. Pedagogical challenges on how to tackle rigid, reactionary worldviews that reflect prejudiced notions of caste, patriarchy and other regressive ideologies are important to address. Another important area that requires attention is the development of skills required to evaluate evidence, particularly in the media regarding various socioscientific controversies. As pointed out, the Indian science curriculum does not pay attention to imparting these skills.

At this juncture, it is also perhaps important to recall an argument made by Rudolph (2005) and Varughese (2012), that with regard to science and the "public", we need to remember that the public is not a homogeneous category. This thesis only discusses work with relatively privileged students who constitute a certain sphere of the "public" - the scientific citizen

public, who would form members of civil society that the scientific community would engage with. Some of them may, in future, become scientists, engineers, doctors themselves. In India, a large population of children and young adults remain unable to access basic education, leave aside an education in science. Conceptualizing critical science education for these sections of society will require serious and dedicated research and will need to be done in conjunction with people living in these communities. Some research projects are underway in India. One example is a project[32] aimed at conceptualizing transformative science education for communities in Mumbai living near a large landfill (Srivastava, Khan & Raveendran, 2016).

I think it is important for me to share that a key learning for me has been that teaching and conducting research in the area of STSE education cannot be done in an objective, dispassionate manner. Even if the ultimate purpose is to teach science (as opposed to teaching ethics, values) using SSIs as a context, researchers/teachers need to be conscious that their ideological positions impact the ways in which they conceptualize research or teach these topics. This thesis reflects a certain vision for science education with an explicit commitment to social and environmental justice. When I embarked on my academic journey in science education, I had not imagined that these commitments could be enacted through science education. Though the explorations reported in the thesis are preliminary, I think their strengths lie in opening up questions – both theoretical and empirical for future work to explore.

32 This is the doctoral thesis work of Himanshu Srivastava, currently a PhD student at the Homi Bhabha Centre for Science Education.

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APPENDIX - I

VALIDITIES IN THE POSITION PAPER ON THE TEACHING OF SCIENCE (NCERT, 2006c)

a) *Cognitive validity* requires that the content, process, language and pedagogical practices of the curriculum are age appropriate, and within the cognitive reach of the child.

b) Content validity requires that the curriculum must convey significant and scientifically correct content. Simplification of content, which is often necessary to adapt the curriculum to the cognitive level of the learner, must not be so trivialized as to convey something basically flawed and/or meaningless.

c) *Process validity* requires that the curriculum engage the learner in acquiring the methods and processes that lead to generation and validation of scientific knowledge, and nurture the natural curiosity and creativity of the child. Process validity is an important criterion since it helps in 'learning to learn' science.

d) *Historical validity* requires that science curriculum be informed by a historical perspective, enabling the learner to appreciate how the concepts of science evolve with time. It also helps the learner to view science as a social enterprise and to understand how social factors influence the development of science.

e) *Environmental validity* requires that science 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, and preparing him / her with the requisite knowledge and skills to enter the world of work.

f) *Ethical validity* requires that the curriculum promote the values of honesty, objectivity, cooperation, freedom from fear and prejudice, and develop in the learner a concern for life and preservation of environment.

APPENDIX – II

EXPLICIT REFERENCES TO ETHICOPOLITICAL CONCERNS

KEYWORD SEARCH

Ethi/Ethical/Ethics/Ethico

Keyword searches of different variants of the root word “ethic” reveal that the word ethical is used in three places. Two of these references are vague and are not elaborated on. However, other references are more elaborate (discussed in chapter 2).

Soc/Society/Social

For the keyword “soc”, one finds references to the social value of flowers in social cultural celebrations (read religious). There are also repeated references to a healthy society and social factors pertaining to health in the chapters on Reproductive health (chapter 4 of the textbook) and Health and diseases (chapter 8). Further in chapter 8, in the section on alcohol and drug dependence, there is reference to violation of social norms and “social adjustment” problems, implying that a concern for the text is to promote social harmony. Only in two instances is the text critical of social norms: those which blame women for giving birth to female children and shun HIV infected individuals. There were some instances where human society was invoked, which seemed innocuous (e.g. “Rheumatoid arthritis ... affects many people in our society”) these have not been presented.

Pol/Politic/Political

The word political appears only in three places. One reference to the word occurs in the preface where it is mentioned that patent laws brought biology to the political domain. This statement has been analyzed in chapter 2 of the thesis. The second reference is merely a statement that refers to the sociopolitical impact of anthropogenic environmental degradation. Since this statement is a part of the introduction to the Unit Ecology, it appears to be a reference to the chapter on Environmental Issues. The third reference is a statement that discusses the need for biodiversity conservation to become a collective responsibility of all nations.

S. No.	Keyword	Chapter title	Excerpt	Page no.
1	Ethi Ethical Ethics Ethico	Reproductive health	Whether to accept/legalise MTP or not is being debated upon in many countries due to emotional, ethical, religious and social issues involved in it.	62
		Molecular basis of inheritance	Address the ethical, legal, and social issues (ELSI) that may arise from the project.	118
		Biotechnology and its applications	Entire section on Ethical Issues (p.213-214) Some ethical standards are required to evaluate the morality of all human activities that might help or harm living organisms	213
2	Soc Society Social	Biodiversity and conservation	There are many reasons (to conserve biodiversity), some obvious and others not so obvious, but all equally important. They can be grouped into three categories: narrowly utilitarian, broadly utilitarian and ethical.	265
		Reproduction in organisms	Flowers are objects of aesthetic, ornamental, social, religious and cultural value – they have always been used as symbols for conveying important human feelings such as love, affection, happiness, grief, mourning, etc	2
		Sexual reproduction in flowering plants	Find out the names of five more flowers that are used in social and cultural celebrations in your family. Have you heard of floriculture – what does it refer to?	20
		Human reproduction	In our society the women are often blamed for giving birth to daughters. Can you explain why this is not correct ?	56
		Reproductive health	However, it has a broader perspective and includes the emotional and social aspects of reproduction also.	57
		Reproductive health	According to the World Health Organisation(WHO), reproductive health means a total a total well-being in all aspects of reproduction, i.e., physical, emotional, behavioural and social.	57
		Reproductive health	Therefore, a society with people having physically and functionally normal reproductive organs and normal emotional and behavioural interactions among them in all sex-related aspects might be called reproductively healthy.	57
		Reproductive health	India was amongst the first countries in the world to initiate action plans and programmes at a national level to attain total reproductive health as a social goal.	57
		Reproductive health	Creating awareness among people about various reproduction related aspects and providing facilities and support for building up a reproductively healthy society are the major tasks under these programmes.	58

		Reproductive health	Educating people, especially fertile couples and those in marriageable age group, about available birth control options, care of pregnant mothers, post-natal care of the mother and child, importance of breast feeding equal opportunities for the male and the female child, etc., would address the importance of bringing up socially conscious healthy families of desired size.	58
		Reproductive health	Awareness of problems due to uncontrolled population growth, social evils like sex-abuse and sex-related crimes, etc., need to be created to enable people to think and take up necessary steps to prevent them and thereby build up a socially responsible and healthy society.	58
		Reproductive health	Better awareness about sex related matters, increased number of medically assisted deliveries and better post-natal care leading to decreased maternal and infant mortality rates, increased number of couples with small families, better detection and cure of STDs and overall increased medical facilities for all sex-related problems, etc. all indicate improved reproductive health of the society.	58
		Reproductive health	Whether to accept/legalise MTP or not is being debated about in many countries due to emotional, ethical, religious and social issues involved in it.	62
		Reproductive health	Absence or less significant symptoms in the early stages of infection and the social stigma attached to the STDs, deter the infected persons from going for timely detection and proper treatment.	63
		Reproductive health	STDs are a major threat to a healthy society.	64
		Reproductive health	Emotional, religious and social factors are also deterrents in the adoption of these methods.	65
		Reproductive health	Our nation was the first nation in the world to initiate various action plans at national level towards attaining a reproductively healthy society.	65
		Reproductive health	What do you think is the significance of reproductive health in a society?	66
		Molecular Basis of inheritance	It is unfortunate that in our society women are blamed for giving birth to female children and have been ostracised and ill-treated because of this false notion.	86
		Molecular Basis of inheritance	Address the ethical, legal, and social issues (ELSI) that may arise from the project (the Human Genome Project).	118

		Human Health and Disease	Agricultural practices, food processing and diagnostics have brought socio-cultural changes in human communities.	143
		Human Health and Disease	(Health) could be defined as a state of complete physical, mental and social well-being.	146
		Human Health and Disease	It is, hence, imperative, for the physical and psychological well-being, that the HIV/AIDS infected persons are not isolated from family and society.	156
		Human Health and Disease	HIV/AIDS-infected people need help and sympathy instead of being shunned by society.	156
		Human Health and Disease	Unless society recognises it as a problem to be dealt with in a collective manner – the chances of wider spread of the disease increase manifold	156
		Human Health and Disease	Adolescence means both ‘a period’ and ‘a process’ during which a child becomes mature in terms of his/her attitudes and beliefs for effective participation in society.	160
		Human Health and Disease	Dependence leads the patient to ignore all social norms in order to get sufficient funds to satiate his/her needs.	161
		Human Health and Disease	(Drug dependency) These result in many social adjustment problems.	161
	Poli/Political/ Politics	Preface	Patent laws brought biology into the political domain and the commercial value of biology became obvious.	P.V
		Ecology	A particular aspect of this is the study of anthropogenic environmental degradation and the socio-political issues that it has raised.	217
		Biodiversity and conservation	Biodiversity shows no political boundaries and its conservation is therefore a collective responsibility of all nations	267

APPENDIX – III

IMPLICIT VALUES CONVEYED THROUGH THE TEXTBOOK

S. No.	Theme	Section in chapter 2 where theme appears	Excerpt	Comment	Chapter	Page no.
1	Anthropocentrism / Utilitarianism	Non Human world	How many living species are there actually there waiting to be discovered and named? […] would we ever be able to complete the inventory of biological wealth in the country? […] nature's biological library is burning even before we catalogued the titles of all the books there.	Employment of vocabulary which commodifies nature.	Biodiversity and conservation	261
			while it is doubtful if any new species are being added (through speciation) into the *earth's treasury of species*, there is no doubt about their continuing losses. The *biological wealth* of our planet has been declining rapidly and the accusing finger is clearly pointing to human activities. (p. 263) Biodiversity and Conservation	Employment of vocabulary which commodifies nature.	Biodiversity and conservation	263
			Humans knew from as early as 8000-1000 B.C. that one of the causes of variation was hidden in sexual preproduction. They *exploited* the variations that were naturally present in the wild populations of plants to selectively breed and select for organisms that possessed desirable characters.	Use of vocabulary that suggests nature as something to be exploited for human benefits.	Principles of inheritance and variation	69
			Besides providing clues to understanding human biology, learning about non-human organisms DNA sequences can lead to an understanding of their *natural capabilities* that can be *applied* toward solving challenges in health care, agriculture, energy production, environmental remediation. (p.119).	Use of vocabulary that suggests nature as something to be exploited for human benefits.	Molecular Basis of inheritance	119

			Plant breeding is the *purposeful manipulation* of plant species in order to create desired plant types that are better suited for cultivation.	Use of vocabulary that suggests nature as something to be exploited for human benefits.	Strategies for enhancement of food production	170
2	Individualized notion of health	Health	Thus, the first use of drugs or alcohol may be out of curiosity or experimentation, but later the child starts using these to escape facing problems. Of late, stress, from pressure to excel in academics or examinations, has played a significant role in persuading youngsters to try alcohol and drugs [...] other factors that have been seen to be associated with drug and alcohol abuse among adolescents are unstable or non-supportive family structures and peer pressure.	Causes of stress are located within the individual as opposed to the larger structure which induces stress to excel.	Human health and Disease	160
3	Population growth	Human population	We have been concerned about unbridled population growth and problems created by it in our country and it is therefore natural for us to be curious if different animal populations in nature behave the same way or show some restraints on growth. Perhaps we can learn a lesson or two from nature on how to control population growth	Hyping population problem	Organisms and populations	229
4	Traditional conservation practices	Non-Human world	Section titled Case study of people's participation in conservation of Forests - The Bishnoi community is known for its peaceful coexistence with nature.	Romanticizing traditional conservation practices	Environmental Issues	284
			You may have heard of the Chipko movement of Garhwal Himalayas. In 1974, local women showed enormous bravery in protecting trees from the axe of contractors by hugging them. People all over the world have acclaimed the chipko movement.	Romanticizing traditional conservation practices	Environmental Issues	285
			In many cultures tracts of forest were set aside, and all trees and wildlife within were venerated and given total protection.	Romanticizing traditional conservation practices	Biodiversity and Conservation	267

APPENDIX - IV

SEX AND GENDER IN THE TEXTBOOK

Feminist scholarship has questioned the correspondence between sex and gender as well as the understanding of sex as binary. Pointing out that both are constructs, they draw attention to variations in both sex and gender identity (Fausto-Sterling, 2000). A keyword search employing the word “gender” yielded no results. However, a simple keyword search employing the words 'women' and 'woman' yielded the results presented in the table below. In each of the excerpts one finds that sex and gender are conflated. In excerpt 1, for instance, female and male are interchangeably used with men and women. Similarly in excerpts 2, 3, 4 and 5, we find women used where female should have been used.

S. No.	Chapter	Excerpts	Page No.
1	Human Reproduction	There are remarkable differences between the reproductive events in the male and in the female, for example, sperm formation continues even in old men, but formation of ovum ceases in women around the age of fifty years.	42
		In some women the hymen persists even after coitus.	46
		Let us remember that hCG, hPL and relaxin are produced in women only during pregnancy.	53
		Oral pills are very popular contraceptives among the rural women	66
2	Molecular Basis of Inheritance	It is unfortunate that in our society women are blamed for giving birth to female children and have been ostracised and ill-treated because of this false notion.	86

APPENDIX - V

PROBE USED FOR INTERVIEWS

Commercial Surrogacy

PART 1

In-vitro-Fertilization (IVF) is a process that has enabled many couples all over the world, who have otherwise not been able to have children through normal biological process, to do so. The process involves extracting the sperm and the egg from the bodies of the parents, or other people (in case the parents are unable to produce these gametes) fertilizing them in artificial conditions outside the body and implanting the embryo in the body of the surrogate mother The surrogate mother has to undergo some hormonal treatment to be prepared to receive the pregnancy and receives payment for for carrying the pregnancy to term.

Do you think IVF is a good technology for people to use when they want to have children biologically?

PART 2

IVF is considered to be a god-sent gift by many childless couples. Also, commercial surrogacy (being a surrogate mother for someone else and receiving payment for it) is serving as a source of employment to many poor women who at least earn about one lakh/pregnancy. Also, since surrogate mothers can be obtained at a cheap rate in India, foreign couples are choosing to avail Indian surrogate mothers' services. A surrogate mother is permitted by law to bear three surrogate pregnancies in her life time. Many people, however, think that surrogacy should not be encouraged because it encourages *only poor women* to come forward and earn money by using their bodies for this purpose.

What are your opinions on the points raised in the above passage?

APPENDIX – VI

PROBE USED FOR WORKSHOPS: WORKSHEET 1

In-vitro-Fertilization (IVF) and commercial surrogacy

Many couples all over the world are unable to have children through the natural biological reproductive process. IVF is a process that enables them to have children artificially. The process involves extracting the sperm and the egg from the bodies of the parents, or other people (in case the parents are unable to produce these gametes) fertilizing them in artificial conditions outside the body and implanting the embryo in the body of the surrogate mother. To prepare the surrogate mother's body to receive the embryo she needs to undergo some hormonal treatment. She receives payment for carrying the pregnancy to term. A surrogate mother can earn in the range of Rupees fifty thousand to a few lakhs per pregnancy.

IVF is considered to be a boon by many childless couples. Also, commercial surrogacy, that is being a surrogate mother and receiving payment for it, is serving as a source of employment to many poor women. Since surrogate mothers can be obtained at a lower payment in India than in other countries, foreign couples are choosing to avail Indian women's services. A surrogate mother is permitted by Indian law to bear three surrogate pregnancies in her life time.

1. Do you think IVF is a good solution for people when they CANNOT have children biologically? Why or Why not? Please elaborate.
(If you cannot make a decision, please write what information you may need to make the decision)

2. Do you think IVF is a good means for people to have children even when they CAN have children biologically? Why or Why not? Please elaborate.
(If you cannot make a decision, please write what information you may need to make the decision.)

3. Do you think that being a surrogate mother is a good source of employment for poor women? Why or why not? Please elaborate.

(If you cannot make a decision, please write what information you may need to make the decision.)

4. Fictitious scenario presented to the students:

Jyoti (32 years) is a mother of three children and lives in a slum in Trombay, Mumbai. She works hard as a house-hold help in 5 houses and has difficulty making ends meet. She meets a neighbour who tells her that commercial surrogacy is a convenient way to make a lot of money. Jyoti is interested in the idea but wonders if the procedure can cause some harm to her body. She approaches you to get more information about the health risks involved. *Suggest different ways in which you can find this information for her.*

APPENDIX – VII

PROBE USED FOR WORKSHOPS: WORKSHEET 2

Group: _____

Members: _____

Internet search

Visit websites that may give information on health risks faced by surrogate mothers. Select 4-5 websites that you consider as providing trustworthy information.

i) *What Keywords did you use to search for information?*

ii) *List the websites you selected as trustworthy and write why you found them trustworthy.*

Name of the website	**Whether in favor of surrogacy or not**	**Reason for finding it trustworthy**
1)		
2)		
3)		
4)		
5)		

iii) *What health risks were mentioned by these websites ?*

iv) *Do you think that the information obtained from these websites is enough to advise Jyoti on whether she should go for commercial surrogacy? Why/why not? Please elaborate.*

APPENDIX – VIII

PROBE USED FOR WORKSHOPS: WORKSHEET 3

Name:

To advice Jyoti on whether there are health risks involved for surrogate mothers you may find information in several ways. One way of gathering information is for *you* to DIRECTLY collect it either by interviewing doctors at fertility clinics or by talking to surrogate mothers.

Source of information	**Why this information <u>may be</u> reliable**	**Why this information <u>may not</u> be reliable**
1. Interview a doctor (gynaecologist*) who runs a fertility clinic where IVF is done routinely. Ask him/her whether surrogate mothers who visit his/her clinic suffer any health problems after the procedure.		
2. Interview a woman who has been a surrogate mother. Ask her to relate her health experiences of the preparation phase, the pregnancy phase and after the delivery.		

- A gynaecologist is a doctor who has specialised in women's reproductive system

A. *Compare the two sources of evidence namely (the Doctor and surrogate mother) in terms of how trustworthy they are (Is one more/equally/less trustworthy than other?). State reasons.*

B. *Do you think interviewing one doctor and/ or one surrogate mother will be enough for you to decide if there are health risks involved in the procedure for the surrogate mother? What more would you need to do?*

INDIRECT methods of collecting information may involve looking up information that has already been collected and written down by *others*. Below are some such sources. Please write down how reliable you consider each of these sources.

Sources of Information	**How reliable do you consider this source (Rate 1-5) 1-least reliable 5-most reliable circle one.**					**Why you consider information from this source reliable**
Newspapers	1	2	3	4	5	
School/college Textbooks	1	2	3	4	5	
Medical Textbook	1	2	3	4	5	
Research Journals (medical journals)	1	2	3	4	5	

APPENDIX – IX

PROBE USED FOR WORKSHOPS: WORKSHEET 4

Article 1

Surrogate mothers in India face discrimination, health risks

(Edited version)

India New England Newsletter, 20/11/2012

By Dipen Hiranwar

According to a recent study by *Sama*, a resource group based in New Delhi that works with women and health issues, surrogate mothers in India are deprived of basic information regarding the various procedures on their body and tests conducted in the course of the treatment.

With the hopes of exposing some of the hidden secrets of the Indian surrogacy industry, *Sama* conducted the study by obtaining crucial and in-depth information by interviewing a wide range of those involved in the Indian surrogacy industry, such as doctors, surrogate mothers, agents.This includes 12 surrogate mothers, 2 agents and 4 doctors from several fertility clinics in Punjab and Chandigarh.

Astonishingly the surrogate mothers are also kept in the dark about many processes and health risks that they have to go though during the treatment. They are also discouraged from asking questions and are not given access to the treatment records, according to the study. As one surrogate mother pointed out,

> For the first three months, I had a lot of trouble. I was in pain since there was injection after injection for three months. There is the gel one. Only after seven–eight days does the pain subside. I took three and then kept aside the rest. I was in tears and did not want any more injections. Already with all the injections there was no place left and then this injection had a thick needle. Imagine the pain.

Surrogate mothers expressed frustration with the unanticipated heavy doses of medication and injections with certain adverse effects on their health. Surrogate mothers reported continued

pain for days following injections, tightening of the skin around the injected area, discoloration of skin and often reducing their mobility for the period. Some reported nausea and lack of appetite, swelling in legs and feet, and weight gain after the pregnancy - unlike any of their previous pregnancies with their own children. In cases of cesarean operations, surrogate mothers stated that the stitches were extremely painful for months.

The report also shows there is no consent from the surrogates regarding decisions such as multiple embryo transfer*, foetal reduction* and cesarean section* delivery. Many cases were found in which the surrogate mothers were told that some of the above procedures were common in the surrogacy process or that the pregnancy would proceed as a normal pregnancy.

*****Embryo transfer refers to a step in the process of assisted reproduction in which embryos are placed into the uterus of a female with the intent to establish a pregnancy. During IVF procedures, more than one embryo is often transferred into the body of the surrogate mother to ensure pregnancy, which is termed Multiple Embryo Transfer. Fetal reduction is done if more than one embryo starts growing in the surrogate mother's body. This involves surgically removing the extra embryo/s. A caesarian section delivery involves delivery through surgical means which involves cutting open the abdomen.

Article 2

Surrogacy: Realizing poor womens' dreams to a better life

(Edited version)

6/12/2011, The Guardian

Divya Gupta

At last ... a European mother cradles her newborn in a clinic providing surrogacy services in Gujarat, India. Photograph: Suzanne Lee/Panos London

Dr Nayana Patel says, "Human beings have two main instincts; the instinct of self-protection and the instinct to reproduce." And she should know – she has carved out a career matching infertile couples with women willing to "rent their wombs". Beginning with a couple of surrogacies a year in 2003, Patel's *Akanksha Fertility Clinic* in Gujarat now delivers about 110 surrogate babies a year.

It's business as usual at the Akanksha Clinic. When Patel arrives one Wednesday morning, the lobby is full of women. Some wear brightly coloured saris; others are in western dress. They are either desperately seeking a baby or hoping to lift themselves out of poverty and offer their own children a better life.

One of the main attractions of surrogacy in India is the price which is a lot cheaper than it is in western countries. Most of Patel's clients are from the US, Canada and Europe.

What do the surrogate mothers feel about their experiences of surrogacy? *The Guardian* interviews two surrogate mothers and the husbands of one other surrogate mothers from *Akanksha Clinic*.

When an accident left 32-year-old Ranju Rajubhai's husband severely burned and unable to work, surrogacy seemed the answer to the couple's problems. "I thought I'll be doing a good deed, my work will also get done and [the couple] will also get a baby," says Rajubhai who is due in a month. Like all the women signed on by Akanksha, Rajubhai will receive $6,225 (about 4 lakh Rupees), the equivalent of seven years wages for her husband. "I will get my husband's surgery done [for his burns]," she says. "I also want to buy a house. It costs $14,500 -$18,500 these days (Between 9 and 13 lakh Rupees). One pregnancy won't be enough, so I am thinking of coming back."

Rajubhai's is a familiar story in the "surrogate house" where she lives with 39 other pregnant women. Owned by Patel, the house is located 10 minutes away from the clinic. With two to three iron-framed beds in each room, the house has the look of a hospital ward. The surrogates, clad in loose, colourful gowns, are sitting, lying, stretching, watching TV or chatting with each other. In one room, hangs a picture of a crawling toddler with the words: "The time to be happy is now."

The majority of the women are second-time surrogates and will have caesarean sections. "We have to cut our stomachs for money," says Anjuman Pathan, a blunt, 30-year-old. "It's not a bad thing, is it?"

Life at the surrogate house creates a sense of sisterhood. The women enjoy the rest and care they may not have had during their own pregnancies but are confined to the house for the whole pregnancy. Their families can visit on Sundays but the surrogates only leave the premises for medical check-ups or if there is a family emergency.

"When I used to go, I would just see the surrogates lying around all day," says Kantibhai Motibhai, the husband of two-time surrogate Shardaben. "They count the days to go back home. [But] I guess it works well. Our main interest was in the money. *Their* (the commissioning parents) main interest is in the baby." Sharda's two surrogacies have allowed the couple to lease some land, buy buffaloes and a motorbike, have money for their children's education and start saving. As second-time surrogate from Nepal, Diksha Gurunga, puts it, "You have to lose something to gain something and what we gain is a lot more than what we lose."

Dr. Patel says laws governing surrogacy in the US, for example, are weighted too much in favour of the surrogate mother. "There are so many cases where you are the genetic parent and [the surrogate mother] is blackmailing you. She will not give you the baby ... If you don't pay, you're not allowed to see the baby. Couples from abroad write to us saying that the legal liabilities are so much in the US, that after paying so much money also, I don't know if I'm going to hold my baby or not and that is what India has taken care of."

Back at Patel's clinic, three women who come from North America to find a surrogate mother are gushing over a newborn European baby recently born to one of the surrogates at the clinic – proof that their dreams could also come true. "There's no perfect system, but given what we have and under the circumstances, Dr Patel's clinic definitely helps create miracles," says Fatima, a Canadian of Indian and Chinese heritage.

Questions posed (for both the articles):

(a) *What position has the author taken in the article? State whether the article is favorable/ unfavorable to surrogacy. Summarize the position in a few sentences.*

(b) *What information/evidence has the author used to support the position taken in the article?*

(c) *Do you think this evidence is enough to support the position? Why or why not?*

(d) *Rate the article in terms of how convincing it is to you on a scale from 1-5.*

1- Least convincing 5-Most convincing. State reasons on why you find it convincing.

APPENDIX - X

LETTERS OF PERMISSION AND CONSENT

The procedure for collecting data involved a visit to the concerned school, followed by a meeting with the school principal who was thoroughly briefed regarding the nature of the study. A letter was submitted to the principal (see 'A' below) following which the principal would contact the biology teachers of class XI or XII based on the nature of the request. Following this, the researcher would interact with the students of the class where they were briefed regarding the study. If they wished to volunteer for the study, they were provided with a letter to their parents (see 'B' below)

A. FORMAT OF LETTER TO SCHOOL PRINCIPAL

(FOR WORKSHOPS/INTERVIEWS)

The Principal, Date:
(address)

Dear Sir ,

My student, Ms. Aswathy Raveendran is a research scholar at the Homi Bhabha Centre for Science Education. Her PhD work involves working with students and making sense of their negotiation of socioscientific issues which are issues at the interface of science technology and society. The specific issues that she has been exploring are related to controversial medical technologies.

It would be very helpful for us and the field of Science Education if you can kindly extend your cooperation once again and permit us to work with/interview a group of ... class XI/class XII biology students of your college in the month/s of..... The format would be a interview/workshop format. We can fix the dates based on the college schedule and students'

convenience.

We request you to kindly facilitate this work.

Thank you.

Regards,

Prof. Sugra Chunawala

B. FORMAT OF LETTER TO PARENTS

Sub: Request for conducting Interview/activities with your ward Date:

Dear Parent,

Homi Bhabha Centre for Science Education (HBCSE), TIFR, Mumbai, is a National Centre for research and development in science and mathematics education. It conducts a variety of field programmes for students and teachers from primary school to introductory college levels. HBCSE has undertaken a project to study students' understanding of certain science-technology-society issues. For this we need to conduct interviews/activities with students of Class XI/class XII.

We request your permission to send your ward for ... hours for ... days starting from .... to …. the The interaction will be audio-recorded/video-recorded.

Where and when?

Venue: Main building, Homi Bhabha Centre for Science Education

Dates: …...

Time: …...

Interested students of Class XI/XII should submit to their teacher the form given below after getting it signed by one of their parents/ guardians.

Aswathy Raveendran
Researcher (mobile:) Signature

(Tear on the dotted line above)

Application for activity/interview sessions at HBCSE

Student's Name:
Class and Section:
School:
Contact Phone Number:
Parent's/ Guardian's signature:

APPENDIX - XI

SYNOPSIS OF PHD THESIS

Chapter 1

Introduction

This thesis seeks to emphasize a vision of science education drawing on critical perspectives that place science within the social, political and ethical context. Broadly, it advances theoretical perspectives that support this position, employing these to critically examine the curriculum documents pertaining to science education, the higher secondary biology textbook (thesis chapters 2 and 3) and reports exploratory empirical work done with higher secondary[33] biology students where they negotiate a controversial socioscientific issue (thesis chapters 4 and 5). I also argue that Critical Science Education (CSE) should persist through higher education and briefly discuss the findings from a study conducted with doctoral students in biology (thesis chapter 6). The empirical work is exploratory and preliminary and intends to illustrate and advance theoretical questions. In this chapter, I will describe the key theoretical ideas that I have drawn from the areas of science education, science-technology-society studies and philosophy of science when conceptualizing and conducting my work.

This thesis can broadly be placed within the area of critical studies in science education (Bazzul, 2016)[34]. These studies critically question the science curriculum, the ideological assumptions that underpin it, and positing alternatives (Bazzul, 2013; Bencze & Carter, 2011; Carter, 2005; Cross & Price, 2002; Hodson, 2003; Raveendran & Chunawala, 2013). However, there are studies which have operationalized these perspectives and conducted empirical investigations involving students and teachers (Bencze, Sperling & Carter, 2012; Levinson, 2007; Roth & Lee, 2004). Many of these studies (both theoretical and empirical) call for inculcating, in students of science and the lay public alike, Critical Scientific Literacy (CSL) and advocate politicization of the science curriculum (Dos Santos, 2009; Hodson,

33 Secondary education in India caters to students between the 12-18 age group, the final two years of which constitute higher secondary education. At the higher secondary level, students choose between the humanities, commerce or sciences, undertaking specialized education in these streams.

34 Bazzul (2016) writes, “The goal of a critical scholar is to render what seems commonsensical, strange”, I interpret this to mean challenge the status quo and mainstream assumptions of what science education ought to be.

2003, 2009; Mayberry, 1998; Weinstein, 2009). Hodson (2011) provides a comprehensive definition of CSL in terms of epistemic, sociopolitical and dispositional aspects:

> ... the most important function of scientific literacy is to confer a measure of intellectual independence and personal autonomy: first, an independence from authority; second, a disposition to test the plausibility and applicability of principles and ideas for oneself, whether by experience or by a critical evaluation of the testimony of others; third, an inclination to look beyond the superficial and to address the ideological underpinnings of science and technology, the economic and political structures that sustain them, and the norms and practices that accommodate some views and some participants but marginalize or exclude others; fourth, sensitivity to the complex interactions of class, race, gender, language, knowledge and power; fifth, an ability to form intentions and choose a course of action in accordance with a scale of values that is self- formulated; sixth, a commitment to criticism and constant re-evaluation of one's own knowledge, beliefs, attitudes and values. (p.27)

Hodson (2003) further suggests an issue-based curriculum to bring about CSL with potential themes around health, land, water and mineral resources, food and agriculture, industry, energy resources, IT and transportation, and ethics. What I argue in this thesis, however, moves beyond advocating critical scientific literacy at the school level for future citizens. Rather, a *critical science education* which places science within its social, political and ethical context needs to persist through to higher education, even in the science curriculum that caters to specialists.

One way through which the goal of critical science education has been realized is through the Science-Technology-Society-Environment (STSE) initiatives in science education. The area of STSE education is broad and its aims appear to fall in two broad categories:

a) To engage learners who are disinterested in science or excluded by the mainstream science curriculum by presenting it in an appealing context

b) To promote the democratic goal of science education, imparting skills to learners to engage with issues that they would have to face as citizens, and to which they will need to apply considerations other than science.

These two goals are different in the sense that the former does not question the content of

science taught in school per se, instead concerning itself with issues of inclusion, while the latter problematizes the science content taught in school and also deals with questions related to ethics, politics and values. The STSE movement in science education arose in response to movements world over in the 1960's and 70's – environmental, pacifist, and the people's health movements which placed academic science under scrutiny, raising critical questions on its impact and accountability towards society at large (Aikenhead, 2003).

In order to understand STSE education in India and how it has evolved, it is important to look at the larger discourses prevalent in the country on the role of science in society. These discourses can be broadly divided into three kinds – First, the 'science for modernization' discourse or what is referred to as the Nehruvian vision of 'scientific temper' (Rampal, 1992) which views science, technology and development as going hand in hand. Second, the 'science for liberation' discourse exemplified in the People's Science Movement (PSM), where science is seen as an emancipatory tool for social change (Varma, 2001). And finally, there is the 'science as violence' argument, put forth by those referred to by Abrol (2014) as Neo-gandhians - who view the nexus of scientific enterprise and the neoliberal state as against the ideals of justice and equity (Nandy, 1988; Rajan, 2005). The dominant understanding of science and its relationship to society that holds public imagination in India is the one of scientific temper (Chadha, 2005).

In India, the need to bring in STSE education up to class X has been recognized in the national curriculum document, but there is no clear articulation of how and in what manner this should be done (Raveendran & Chunawala, 2013). However, there has been a history of out of school/non-formal educational initiatives that have attempted to bring in these concerns, such as those helmed by the people's science movements (Kannan, 1990). Several initiatives at the higher education level have also aimed at bringing in the social and historical context of science into the science curriculum (Raina, Pattanayak & Valte, 2009).

In the west, the socioscientific issues (SSI) movement in STSE education emerged in response to the perceived limitations of the STSE approaches, which were seen as diffuse and theoretically under-evolved (Zeidler, Sadler, Simmons & Howes, 2005). SSIs are “social dilemmas with conceptual or technological links to science” (Sadler, 2004). These are typically ill-structured, real world issues that are controversial in nature. The nature of SSIs are such that “facts are uncertain, values in dispute, stakes high and decisions urgent”

(Funtowicz & Ravetz 1995). These represent cases of science in the public domain that is characterized by uncertainty and require value considerations other than scientific evidence to resolve. The need to introduce SSIs in the school and undergraduate curricula has been recognized by the international science education community as well as by the national curriculum documents in several countries (Hughes, 2000; Zeidler & Keefer, 2003). Research has systematically explored students' negotiation of SSIs examining different factors that affect the reasoning and the argumentation strategies that students adopt (Sadler, 2004).

It is also important to remember that different epistemological frameworks of understanding the science-society interface inform how different researchers understand the issue of negotiation of SSIs. Levinson (2007) discusses these frameworks on the basis of how technocratic they are. Technocratic frameworks of understanding the science-society interface stress the importance of canonical scientific knowledge in resolving the issue and view scientific experts as solely capable of arbitrating on it. In non-technocratic frameworks of science-society interface, the central role of science in resolving the controversy is not privileged and the science needed to negotiate the issue is seen as tentative and uncertain. Scientific knowledge may also be critiqued and challenged in this model. I adhere to a non-technocratic model of science-society interface and this will be reflected in the theoretical frameworks that I draw upon in the studies reported in the thesis.

Adhering to a non-technocratic framework of understanding the science-society interface does not automatically translate to a rejection of science. To be sure, science has to its credit an impressive array of methods, tested and refined over the past few centuries. However, there is also a certain image of science that exists in the popular imagination and propagated through the textbooks that portrays the nature of knowledge as insular, value free and authoritative (Rudolph, 2005). This image of science has consequences in the way the public receives it - there is an unquestioned reliance and lack of criticality in their evaluation of scientific developments. Lack of understanding of the nature and limits of scientific knowledge also makes experts non-responsive to the needs of the public.

There is a wealth of philosophical literature that looks at the nature and purposes of scientific knowledge from the perspective of its role in society (Allchin, 1999; Kitcher, 2003; Longino, 1983, 1987, 2006; Rudolph, 2005). I employ these to argue that creating a dichotomy between STSE topics and academic science content in terms of viewing the former as value-laden and

the latter as value-free reinforces the “myth of purity” of academic science. Engaging with the contentious philosophical aspects of the academic science content along with a discussion of topics that fall within the STSE category is necessary for students who are training to be scientists inorder to be more humble and reflexive with regard to the knowledge that they produce. Likewise, those students who are not training to be scientists also stand to gain from understanding the nature and limits of scientific knowledge.

Next, I review perspectives from philosophy of science and science studies that discuss science's relationship with society (Fig. 1).

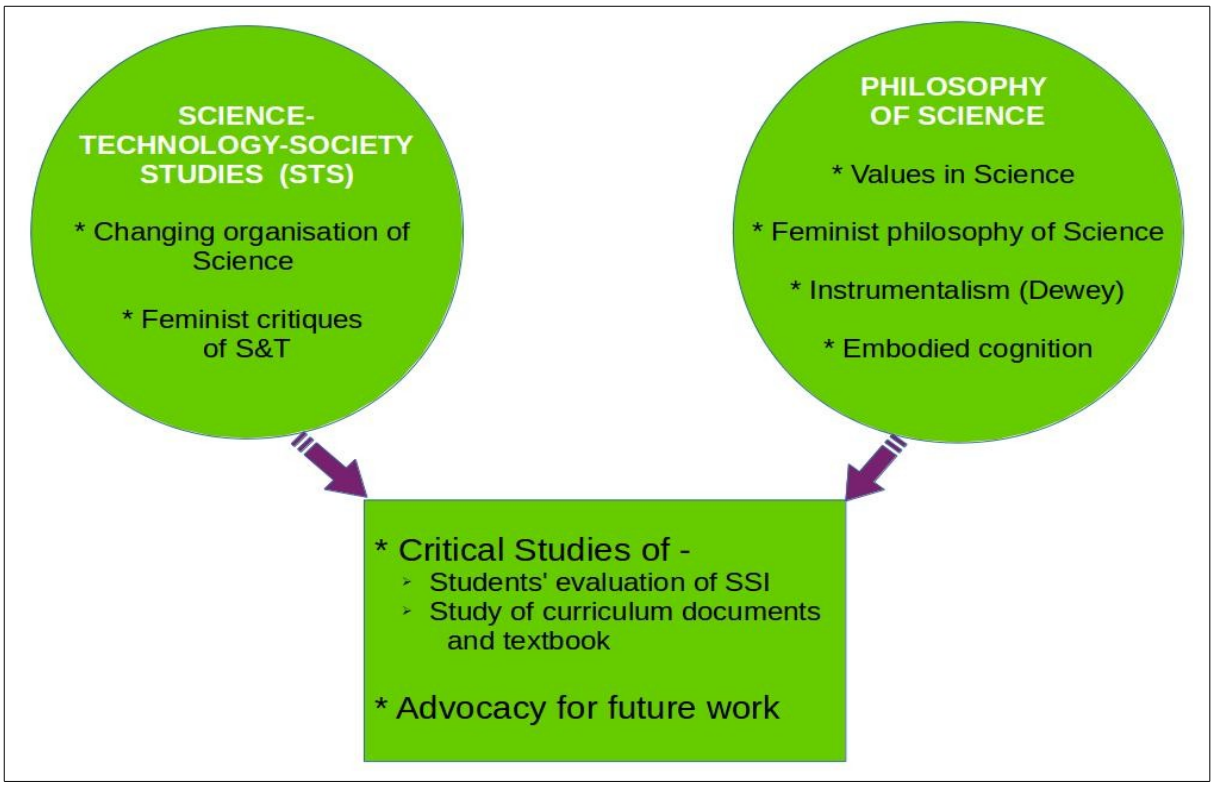

Fig. 1: Philosophical perspectives informing the work in the thesis

As Howard (2009) points out, “Science in a social context is science influenced by values, motives, social interests, and political agendas” (p.202). In fact, the fact-value dichotomy[35] maintained “even” in the so-called pure sciences has been questioned (Laudan, 1984; McMullin, 1983; Putnam, 2002). These views have been succinctly summarized by Allchin (1999). Pointing out that the fact-value dichotomy is not as sacrosanct as popular conceptions regard it, he reviews literature in philosophy and sociology of science which discusses the

35 A major proponent of the fact-value dichotomy was David Hume, according to whom statements pertaining to what *is*, or those which are matters of fact need to be seen as different statements that refer to what *ought* to be, or which are statements of value (Reiss, 1999)

relationship between science and values, identifying three broad ways in which they interact. Firstly, there are values of science which are values internal to science or epistemic values – what scientists regard as necessary values when engaging in scientific inquiry – such as novelty, accuracy, simplicity, precision, repeatability, keeping at bay error, fraud, research ethics and so on. Secondly, values from larger culture could enter science through individual practitioners. For instance, the work of feminist philosophers of science have exposed androcentric values inherent in different areas of scientific research (Longino, 1983, 1987). Finally, values from science – both as a product and process get exported to society. Certain values regarding science are held by society or the public at large – that it is objective and hence, scientific evidence qualifies as the final arbitrator of any socio-scientific controversy. He cautions against this conception and discusses how, in risk assessment particularly, where scientific evidence is uncertain, values other than science may play a role in resolving the issue. He also discusses briefly the intersection between new technology and values, pointing out that new technology can either raise new values[36] or radically challenge fundamental values[37].

The post-positivist turn in philosophy of science is also beginning to question notions of whether science faithfully represents reality and more importantly, what are the larger motives guiding theory building in science. Drawing from philosophers of science like Dewey, these perspectives reiterate the need to view the primary function of thought and knowledge as directed towards action/modification of environmental conditions (Colucci-Gray, Perazzone and Dodman, 2013; Levinson, 2010; Rudolph, 2005). According to this instrumental view, knowledge should be viewed primarily as an intellectual tool that addresses human needs, which not only meets practical needs but also serves to understand the world. Kitcher (2003) puts forth a similar perspective elucidating, through different examples, how models of naïve realism – which posit that a unified, true depiction of the world can be arrived at through methods of science – do not hold true anymore and why there is a need to understand that a network of practical and intellectual concerns drive scientific inquiry which are contingent on historical, social and cultural context. Rudolph (2005) points out that these ways of understanding science, counter to the view that is propagated in textbooks that portray it as purely disinterested pursuit of knowledge, opens it up for public scrutiny. Aside from these

36 He discusses the example of organ transplants, pointing out that though they preserve the value of life, they also raise new values, such as issues of equitable access.

37 He discusses the example of new reproductive technologies and how they conflate the concept of parentage.

aspects, tools like language play an immensely important role in how we construct knowledge and the metaphors we use reflect the social and cultural context within which science is done (Colucci-Gray et al., 2013; Martin, 1991).

Recent work in science studies in the last two decades have also pointed out that the organization and institutionalization of science is changing, which is in turn impacting the nature of science. One of the major forces is commercial interest, followed by the rupture of traditional disciplines confined within universities. Science is moving out of the laboratories and we see that it is increasingly being produced within the context of application – as evident in the recent advancements in genomics, robotics, nanotechnologies and so on (Funtowicz & Ravetz, 1995; Nowotny, Scott & Gibbons, 2003). Put differently, the traditional dichotomy between representing and intervening is breaking, and the new knowledge which is *actionable* in nature demands ethical evaluation (Basu, 2015).

Bringing it all together, I would like to point out that this thesis is primarily an exposition of an alternative view of what a science education that aims to inculcate critical perspectives on science and social justice concerns *could be.* In accordance with this vision, I report three studies in this thesis. Study 1 (reported in chapters 2 and 3) examined the school science curriculum documents, and one textbook - the higher secondary class XII biology textbook with a focus on how it approaches the fact-value dichotomy. Study 2 (reported in chapters 4 and 5) involved empirical studies with higher secondary students with a focus on the value considerations (epistemic and non-epistemic) that students bring to bear on a socio-scientific issue related to commercial surrogacy. In chapter 6, I argue that critical science education should persist through to the PhD level and report findings of Study 3 involving PhD students, where the epistemic and non-epistemic criteria that students generate while evaluating genetic determinism are explored. The thesis does not compare any of the reported studies, but aims to, a) Point out that the manner in which social, political and ethical concerns are discussed in the existing school science curriculum leaves a lot to be desired, b) Demonstrate ways in which one can design educational experiences that can expose students to the interaction between science and values in context, and c) Advocate a vision for critical science education at all educational levels.

Chapter 2

Social, political & ethical concerns in the science curriculum documents and higher secondary biology textbook

There are several initiatives in science education that have tried to engage with the issue of values [38] in science and how to bring an awareness of these concerns into the science curriculum. The STS movement in science education (Aikenhead, 2005), for instance, seeks to teach science and technology by placing them in the larger social, political and ethical context. Unlike many science curricula worldwide that have emphasized STS education, the Indian science curriculum is yet to embrace these concerns in a major way (Raveendran & Chunawala, 2013). This chapter will report an analysis of school science curriculum documents (NCERT, 2006b; 2006c) as well as the class XII biology textbook (NCERT, 2006a) with a focus on how these present social, political and ethical concerns in terms of the ideals of critical science education.

The higher secondary science curriculum represents a level where disciplinary pressures operate, so it becomes interesting to analyze how STS concerns get treated by the curriculum and textbooks at this level. Can these concerns be omitted from the curriculum? Is a value-free rendering of scientific and technological applications possible? These concerns brought me to analyze the higher secondary biology textbook.

Before I turn to the analysis, I discuss why examining textbooks and the curriculum documents is necessary. Textbooks represent sites where dominant values and ideologies get selectively and authoritatively transmitted, (Apple, 1990) thereby making it necessary to critically analyze them. The discourse in science textbooks become particularly important to examine because they have the quality of speaking “the truth” authoritatively, making it important to question their assumed objectivity (Bazzul, 2013).

The methodology that I employ in my analysis would fall within the tradition of critical discourse analysis (Fairclough, 1989), which predicates itself on the understanding that language is a social activity, where it is viewed not just as a reflection of larger social structure, but as something that actually impacts wider social structures. Fairclough introduces a methodology to examine texts in terms of vocabulary, grammar and textual structures. The

38 The term “value” is used to denote notions pertaining to “what ought to be” and could also include epistemic values. In this chapter, however, I use the term value to denote social, political and ethical concerns.

analysis will pay attention to these aspects as well, wherever they are apparent, highlighting words and phrases in the text that suggest adherence to certain ideologies. I will then contest these ideological positions from alternative standpoints. The validity of my interpretation is open to the reader to judge based on the force of my counterarguments, and the kind of evidence I bring to bear on my arguments.

The analysis begins with an examination of the National focus group's position paper on the 'Teaching of Science' (NCERT, 2006b) which provided recommendations for textbook writing, both at the national and state level. I find that the position paper gives primacy to facts over values as evident in the positivist understanding of the nature of science, the view that science can alleviate all social problems and the vision for scientific literacy that emphasizes learning of facts, principles and theories:

> Facts, principles, theories and their applications to understand various phenomena are at the core of science and the science curriculum must obviously engage the learner with them appropriately (NCERT, 2006b, p.12).

Prescriptions for science education at the higher secondary level in the position paper also marginalize STS concerns, deeming it unworthy of “formal assessment”. On the other hand, the higher secondary biology syllabus document (NCERT, 2006c) mentions the need to introduce ethical issues in the textbook:

> The syllabus also takes up issues pertaining to environment, health and other ethical issues that arise with any interference of human beings in the natural processes, which have great relevance from the societal point of view (p.1).

In my analysis of the class XII biology textbook, I do two things 1) Examine what the textbook *explicitly* brackets out as values - ethical and political concerns, 2) Examine *implicit* values conveyed when discussing topics that are at the interface of the scientific and social world that relate to human life and its regulation, as well as the relationship of humans with non-human world. These topics include: human health, gender and sexuality, population as well as non-human life forms in relation to human needs (biodiversity and environmental issues). These topics were chosen as they are often discussed in STS literature. As Viswanathan and Parmar (2002) and Basu (2015) point out, any ethical discussion on the new technosciences cannot preclude the discussion of risk. The estimation of risk, by its very

nature is a value-laden exercise (Douglas, 2000). Hence I discuss how risk is treated in the textbook as well.

The textbook does make some explicit references to ethical and political issues. For instance, the preface states that, “Patent laws brought biology into political domain and commercial value of biology became obvious” (p.V). The sense that gets conveyed through this statement is that the politics around biological knowledge and applications are confined to issues related to patent laws and intellectual ownership. This is further developed in the section on “ethical issues” in the chapter 'Biotechnology and its applications' where there is a predominant focus on issues of piracy. There is only a cursory mention of the existence of ethical concerns in discussions on medical termination of pregnancy in the chapter and fertility enhancing technologies in the chapter on reproductive health and the human genome project in the chapter on molecular basis of inheritance.

Apart from explicit discussions of ethical and political concerns, dominant, mainstream values are conveyed *implicitly* in the discussion of several topics. For instance, in a discussion related to health, it is stressed that a healthy body is eventually needed for “economic prosperity” while sociopolitical factors of health are sidelined. Similarly, for topics pertaining to gender and sexuality, we find cis-gendered bodies and heterosexual, monogamy being promoted as the norm and those that deviate from this norm being pathologized. Fig. 2, for instance, depicts two individuals who have (a) Klinefelter's syndrome and (b) Turner's syndrome. What is marked out as a “disorder” is the presence of feminine character in the male and the absence of it in the female.

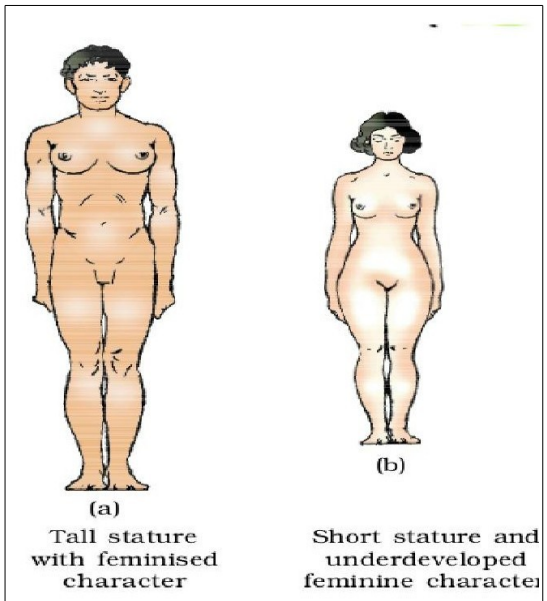

Figure 2
Pathologising infertile bodies

When discussing the non-human world, the textbook has adopted a largely anthropocentric focus where human life is valued over other forms of life, a recurring theme in the textbook being the need to feed the increasing population of the world and harness the extended non-human world in service of this agenda.

Thus we find a range of ideological positions held by the textbook on various topics. While, on the surface, the textbook discourse promotes values that support (often regressive) agendas of the state, there are also undercurrents of resistance against these agendas as evident in the discussion on conflicts around topics such as the green revolution technologies and e-wastes and nuclear waste. On the one hand, for certain topics such as nuclear waste, public resistance and issues of risk are acknowledged while on the other hand for topics such as reproductive health, the state's regressive agendas of top down fertility control is promoted (discussed in detail in chapter 3). However, there is no acknowledgement, in any sense, of the epistemological as well as political critiques raised by the womens' health movement. Somewhere in between, we have topics such as biotechnology where public resistance or environmentalists' concerns regarding risks are sidelined, while issues like biopiracy are discussed.

Though, admittedly, there is some acknowledgement of risk around certain technologies, the textbook does not pay any attention to the skills needed to evaluate the nature and extent of risks. I also observe that knowledge in the textbook is treated as a commodity, with focus on questions of patenting and ownership. Indigenous knowledge is viewed as something that can be tapped into by modern science, through patenting regimes. Besides, the nature of indigenous knowledge is not dwelt upon and even in sketchy discussions of topics like *Ayurveda*, indigenous knowledge is portrayed as inferior to modern western science.

In summary, though one can observe that the values and ideologies expressed in the textbook are conflicting and do not reflect any particular monolithic agenda, one also gets the sense that careful attention is not being paid to the kind of values that are getting conveyed by the textbook. This treatment is consistent with the position paper's advocacy for science education at the higher secondary level, which gives primacy to teaching facts and relegates STS concerns to the periphery. I, therefore, argue that it is important that textbooks begin to reflect the value conflicts around the technosciences as well as topics that fall within the science-society interface. Besides, committees that write textbooks need to acknowledge value conflicts inherent in these topics as well as think through which values, why and how need to be incorporated, with the understanding that values cannot be kept out of discussions related to these topics. Ignoring value conflicts can result in regressive and oppressive agendas of the state and neoliberal global capitalism percolating into the textbook. Hence, science textbook

writers need to engage with the wide range of STSE scholarship existing in the country and worldwide.

Chapter 3

Reproducing values: A feminist critique of reproductive health in the higher secondary biology textbook

In this chapter, I closely discuss one chapter on reproductive health in the class XII biology textbook (reported in Raveendran & Chunawala, 2015) using a feminist lens. Here too, the focus is on the kind of values that are being conveyed in the discussion on reproductive health, bringing to bear on the analysis, feminist scholarship in India that has critiqued reproductive health policies of the state (Manorama & Shah, 1996; Narayanan, 2011; Qadeer, 2009, 2010), as well as the technologies that have been promoted by these policies. The reason for this in-depth discussion on the chapter on reproductive health is because it affords a context to discuss the next two chapters of the thesis (4 and 5), which present higher secondary biology students' negotiation of a socioscientific issue related to commercial surrogacy. The methodology adopted to analyze the chapter is critical discourse analysis (discussed in chapter 2).

The textbook chapter is critiqued in three ways. The first part discusses how reproductive health is defined with a focus on 'whom' and 'what' this definition includes and excludes. The second and third parts have been devoted to critiquing how population control and infertility are presented drawing on feminist critiques of these technologies.

When discussing the definition of reproductive health, the textbook reiterates the idea of *normalcy* of reproductive organs and behavioral interactions between the sexes:

> The term simply refers to healthy reproductive organs with **normal** functions. However it has a broader perspective and includes the emotional and social aspects of reproduction also... according to the World Health Organization (WHO), reproductive health means a total **well being** in all aspects of reproduction, i.e., physical, emotional, behavioral and social. Therefore, a society with people having physically and functionally **normal** reproductive organs and

> **normal** emotional and behavioral interactions among them in all sex-related aspects might be called reproductively healthy (p. 57, emphases added).

While the term 'well being' (used by the WHO) acknowledges the individual's subjectivity in her experience of reproductive health; the term 'normal' takes away this individual experience connoting an external, scientific standard of reproductive health, defined by functionality of organs. This definition excludes people of sexes other than the socially accepted male and female sexes. Apart from this, the phrase 'normal behavioral and emotional interactions' also appears to pathologize people with different gender identities or sexual preferences whose experiences of reproductive health may be very different. Such definitions based on the idea of normality make it easier to propose technological fixes to correct abnormalities. What is also interesting is that the WHO definition, which emphasizes *well being* as central to reproductive health is interpreted by the textbook as referring to *normalcy* in functioning of reproductive organs (which essentially means bodies which are capable of procreation) and 'normal behavioral interactions between individuals which essentially delimits admissible sexuality to that of the Malthusian couple. In effect, what Fairclough (1989) refers to as a relation of synonymy has been established between the words well being and normal, which are otherwise semantically very different.

Feminist critiques of reproductive health policies of the state (Narayanan, 2011; Rao, 2000) point out that the population control policy of the state has been top down and coercive. Collaborative approaches to population control, which focus on overall social and economic development (providing access of the population to health, education, food, water etc) have been known to work better (Sen, 1994) in regulating population. Besides, policies on reproductive health needs to be evaluated in the context of the larger changes in the health sector, where we see a withdrawal of the state from investing in public health (Rao, 2000). The textbook, however uncritically promotes the population policy of the state.

The textbook chapter also appears to be devoted to the uncritical marketing of technologies used to facilitate reproductive control and fertility assistance. Dry, technical descriptions of fertility control technologies take up large sections of the chapter. Side effects and users' experiences of these technologies are sidelined, as evident in this sentence:

> No doubt, the widespread use of these methods has a significant role in checking uncontrolled growth of population. However, their **possible** ill-effects like nausea,

> abdominal pain, breakthrough bleeding, irregular menstrual bleeding **or even** breast cancer, **though not significant** should not be totally ignored (p. 62, emphases added).

The women's health movement has raised epistemological as well as political questions on many of these technologies which are harmful. Yet, there is no mention or acknowledgement of the issues raised by the movement. Other important dimensions of reproductive health like maternal and child well being, control of STDs, pregnancy and medical termination of pregnancy are discussed but not given priority. The negligible space devoted to the discussion of these topics is an indication of this.

The textbook's latent function appears to be that of serving the state agenda of reproductive control of its citizens, particularly women, through the use of technology. This is manifested in its celebration of the population control policy as well as the discussion of fertility enhancing technologies, with limited scope to questioning the role of these technologies in reinforcing patriarchal notions of genetic parentage. Importance of the knowledge of the menstrual cycle and the efficacy of natural and less invasive contraceptives are underplayed while chemical and more invasive technologies are celebrated paying only lip service to the serious side effects associated with these technologies. There are no possibilities afforded by the textbook to question the very need of these technologies.

One of the professed aims of the curriculum at this stage is to create future scientists, technologists and medical practitioners (providers of these technologies). In the context of this aim, the absence of any discussion on side effects of the various contraceptive and fertility technologies is worrisome because it implies that the users' perspective or experiential meaning of the technology does not matter in a curriculum catering to the providers of these technologies. The text also promotes technocratic solutions to birth control and fertility assistance, inadvertently suppressing the socio-political dimensions pertaining to these aspects. Thus, values and ideologies motivate decisions on what should qualify as 'content' in the textbook. Interviews with three teachers who teach the topic reveal that they view the topic as value-laden. However, the values that they wished to communicate were largely related to issues surrounding marriage and sexuality.

Recalling the discussion in chapter 2, from the point of view of critical science education, I emphasize that careful attention needs to be paid to what values textbooks convey. Textbook

writers and teachers need to understand that discussion of technosciences cannot happen in a sterile manner without bringing in value-positions.

Chapter 4
Students' Negotiation of Commercial Surrogacy: Ethico-Political and Epistemic Concerns

How do students, in the absence of any formal educational exposure, deal with real world socioscientific issues? In this chapter, I report an exploratory study where students encountered and negotiated a socioscientific controversy. The issue presented to the students was commercial surrogacy, which is related to In-Vitro-Fertilization, a technoscience fraught with conflicts which are ethical, political and scientific in nature. A total of 39 students participated in the study, of whom 20 were interviewed and the remaining 19 participated in workshops that involved interactive sessions, group work and debates. Both the interviews and workshops employed questionnaires (Appendix V - IX) on the basis of which discussions took place. The interviews were audio-recorded while the group interactions were video and audio recorded.

Students' responses have been illuminated using a theoretical framework proposed by Ralph Levinson (2006). The epistemological framework helps to unpack what is at stake in a controversy in terms of Levels of Disagreement[39] (LoDs) in a systematic and structured manner. The levels of disagreement represent different aspects/layers of the controversy that pertain to evidence, values or worldviews. There are nine LoDs and the direct role of evidence in resolution of the disagreement diminishes as we move from level 1 to level 9. Table 1 discusses commercial surrogacy in terms of the different levels of disagreement.

The **description** of the levels in Table 1 (as discussed in Levinson, 2006, verbatim):

Level 1- Disagreement related to evidence which could in principle be forthcoming would be available at some point

Level 2- Disagreement related to evidence which is “conflicting, complex and difficult to assess”

Level 3- The criteria needed to resolve the controversy may be agreed upon. But disagreement on weightage needed to be given to these criteria.

39 Levinson (2007) derived this framework on the basis of Mc Laughlin's framework which outlines what is at stake in a controversy in a pluralist, democratic society

Level 4- Disagreement related to lack of consensus between the parties on ethical premises.

Level 5- Disagreement related to difference in interpretation of concepts involved.

Level 6- Disagreement related to different perspectives that arise due to difference in interest positions.

Level 8[40]- Disagreement due to differing 'total experiences' of people involved.

Level 9- Disagreement related to the entire frameworks of understanding/world-view differences.

Table 1

LEVEL 1 and 2	LEVEL 3	LEVEL 4	LEVEL 5	LEVEL 6	LEVEL 8	LEVEL 9
-Health risks to the surrogate mother, biological mother, child -Success rate of IVF procedure	Concerns related to affordability and access	Does surrogacy amount to trading the body? And is this acceptable ?	-What constitutes 'family'? Does lending genetic material amount to parenthood?Need for genetic family (ensured through ART) versus Need for social family (ensured through adoption) -Are the surrogates making a 'choice' to rent their wombs? Is a choice motivated by poverty a free choice? -Are the surrogate mothers being exploited? Can someone choose to be exploited?	If participants look at commercial surrogacy from the interest position of commissioning parents, they may see it as justified. But from the perspective of surrogate mother, is it justified?	An adopted person may have strong positions on the issue	Worldview differences stemming from Religious concerns that view IVF/ Surrogacy as unacceptable

Table 1: The issue of commercial surrogacy discussed in terms of Levels of Disagreement

Students raised multiple social and ethical concerns towards the issue (Fig. 3). These can be grouped into bioethical concerns (further classified into concerns related to harm, concerns related to access, concerns related to autonomy and choice), concerns stemming from

40 Level 7**,** According to Levinson (2007), can be subsumed under other levels. He does not develop level 7 further.

differences in worldviews (those related to the nature of the family, religion, social acceptability of the surrogate mother), economic concerns (those discussing development of the nation, concerns related to women's economic independence) and epistemic concerns (those invoking scientific knowledge and evidence).

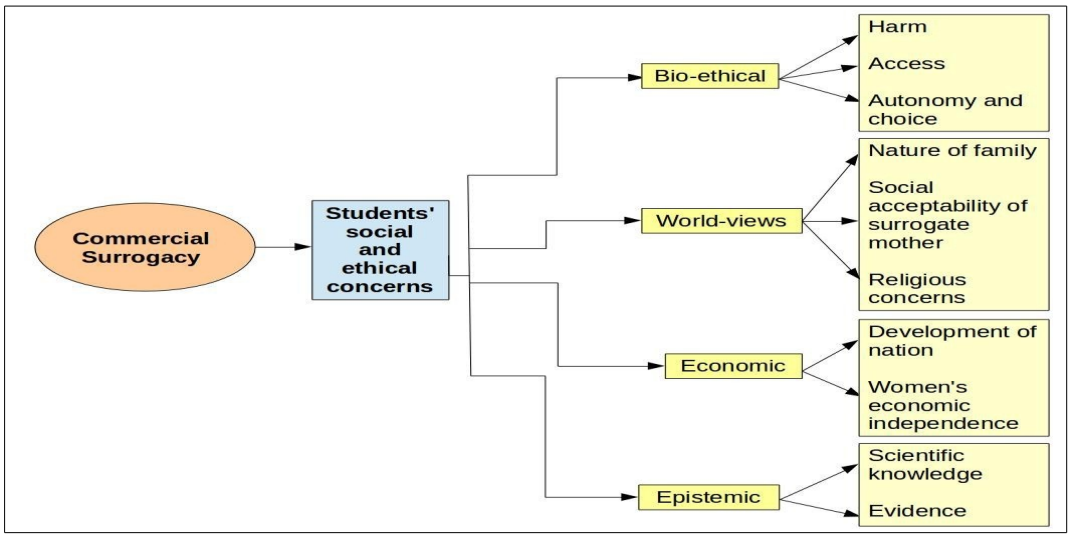

Fig. 3 : Social and ethical concerns raised by the students

Except for a few students who questioned the very need for the technology in terms of whether having one's own biological child is necessary or not, most students were accepting of the technology and its potential to offer a solution to infertility. Nevertheless, when probed, many of them raised pertinent questions, which included questions about risks to users.

In terms of Levinson's levels of disagreement, these concerns could be taken up for discussion at multiple levels. At level 1 and 2, several students raised questions as well as concerns related to the extent of health risk posed by the technology to various users. Preliminary explorations in the interview suggested that students needed support to understand the nature and extent of risk. To this end, I (along with another facilitator) conducted a set of structured activities to elicit their understanding of different sources of evidence and their reliability (discussed in the next chapter).

Students also raised considerations that could be pitched at level 3. In some instances, we found them conducting cost-benefit analysis, where they weighed one concern against another. For instance, there were group discussions around whether access for all is a necessity when it comes to IVF. This is an important point to raise for any technology, but

some students felt that the technology need not be accessible to the poor because they are unable to take care of their children anyway. This is obviously a prejudiced view and a teacher would need to intervene and raise questions on whether this is a desirable way of framing the question. Questions could be raised such as, is the right to procreate, a universal right? Should the government funds for health care be spent on making services like IVF available through the public health care system?

Another level 3 disagreement that students appeared to grapple with was whether the health risks posed by the technology could be traded off for the financial gains that the surrogate mother would have by engaging in surrogacy. Students arrived at different decisions on whether the money that she was making was sufficient, taking into consideration the health risks that she is likely to endure. One of the key issues that need to be addressed in order to resolve the disagreement would be to ascertain the levels of risk involved for the surrogate mother, as well as the acceptable levels of risk, which would in turn require a careful evaluation of the evidence available.

At level 4, students indicated disagreements on the basis of differences in ethical or value premises. For instance, we witnessed an exchange between a boy and two girls, where the boy was deeply troubled by the idea of the surrogate mothers' body being treated like a commodity and being “traded”. While one of the other participants in his group appeared to see his point of view after some persuasion, the other student remained indifferent. Handling these disagreements may prove difficult for the teacher, who may have to illuminate different points of view and ensure respect for diverse views. At level 4, we also had students raising concerns and debating on the need for technology in terms of whether a family based on genetic relationships is necessary. Here too, it may be worthwhile to interrogate views that stress the need to maintain sanctity of the bloodline as some of these appeared to come from casteist perspectives. Educators/teachers could also raise questions on the nature of infertility - whether it is a biological problem rooted in notions of genetic relationship or a social problem.

Disagreement at level 5, which involves differences that may arise due to alternative ways of interpreting a concept was also apparent in the interviews as well as group discussions, especially views which questioned the idea of a family. One student, in his interview, raised a fundamental point about the nature of the family when he suggested that one can always treat

someone as one's family. He seemed to understand the term “family” differently from most other participants, who did not question the notion of family premised on genetic relationships. Another disagreement at level 5 emerged when students debated on the nature of “experience” a surrogate mother would have, after going through the IVF procedure regarding the side effects and risks posed by it as compared to a doctor, who has a specialized knowledge regarding IVF. Disagreements at both level 4 and level 5 may not be easy to resolve as these differences often stem from considerations that arise from different ethical or value premises. However, these differences ought to be discussed in the classroom, and the teacher could help illuminate differences in premises and consideration of alternative viewpoints.

At level 6, we found students raising concerns based on the interest positions they assumed in terms of different stakeholders involved in the technology. From the perspective of critical science education where there is an explicit commitment to equity and social justice, it might be important to get students to evaluate the technology from the standpoint of the most marginalized user of the technology, and in this context, the surrogate mother and the risks the technology would pose to her body. Though many students took positions that were concerned about the surrogate mothers health, some found it difficult to evaluate the technology from the surrogate mothers' point of view.

It was difficult to gauge whether any of the student responses could come from deep rooted personal experiences (level 8) as our interactions with the participants were for a limited time. Nevertheless, there is reason to believe that this may have a role in shaping their views at various levels. At level 9, we see participants arguing on the basis of religious beliefs. Arguments at this level would be a challenge for teachers to handle, particularly those views that are regressive and reinforce notions of caste and patriarchy. It is not clear whether all the students subscribed to these notions, because some of them would often *other* these worldviews as something that the extended “society” harbors. This was evident in the debates around the desirability of a biological family vis-a-vis a social family. As Levinson (2007) points out, arriving at a consensus for participants who argue on the basis of differing world views is difficult. So the task for the teacher would be to encourage different worldviews on both the sides and facilitate the development of empathy and mutual tolerance. In this context, it may also be important to keep in mind the point made by Levinson (2007) where he asserts that racist, sexist or other anti-minority views are not to be viewed as controversial since

views that oppose equality of human beings are not rationally defensible, and these views cannot be aired in a classroom context, in a climate of mutual respect and tolerance. Therefore, views that are openly prejudicial need to be challenged by the teacher.

To sum up, Levinson's LoDs were helpful as a theoretical framework to parse out the issue of commercial surrogacy in terms of multiple levels. Students' viewpoints were also evaluated from the perspective of critical science education, which premises itself on normative ideals such as social justice and emancipation, which in turn entails a commitment to countering and resisting hegemonic structures such as patriarchy, caste and capitalism. What we witness is that students bring a wide range of social, ethical and political considerations regarding the controversy, indicating a spectrum of worldviews. From the point of view of critical science education, the existence of student discourses that supported inequalities related to class, caste and gender is worrisome. Working with students who harbor reactionary perspectives may prove to be a challenge. There were certain views that could be associated with minority groups as well (those related to religious beliefs, for instance), which will need to be carefully and sensitively addressed, if brought up in the classroom.

Chapter 5

Students' Negotiation of Commercial Surrogacy: Evidence Evaluation

There is general consensus that one of the many skills that would help in arriving at informed decisions regarding socioscientific issues is the ability to evaluate evidence, though not the most important one. Nielsen (2013), for instance, points out that socioscientific deliberation is not just about what is true, but what to do and hence requires the integration of values and facts. Students need skills to integrate factual information, if they perceive it as necessary in their deliberations of socioscientific issues. The reported study was conducted to document ways in which students evaluate evidence related to the risk posed by the procedure of surrogacy and its impact on the surrogate mother's health.

This study involved 13 students of class XI who engaged in a series of structured activities (reading and debating around questionnaires) that closely examined their understanding of various aspects of evidence evaluation. The interactions were conducted in a workshop format spanning two days. Students worked on four worksheets individually (Table 2), discussed

these worksheets in student-only groups and with facilitators. Their discussions and interactions were video and audio-recorded.

Worksheet	Purpose
Worksheet 1 (Q.4) *Fictitious scenario involving a potential surrogate mother who wishes to get information on health risks posed by the procedure. She approaches the student to find some information for her. Students are asked to list potential sources of evidence that they would look for.*	*To elicit students' understanding of primary and secondary sources of evidence*
Worksheet 2 *Internet research activity where students were asked to locate reliable websites that host information on health risks related to surrogacy*	*To elicit students' understanding of how to evaluate secondary sources of evidence: Do students critically examine the sources from where information is derived? Do they evaluate the websites in terms of who hosts them?*
Worksheet 3 *Students were asked to compare between primary sources of evidence: the doctor and surrogate mother.* *Students were asked to assess 5 sources of secondary evidence and judge their reliability: Newspapers, School and college textbooks, Medical textbooks and Research Journals.*	*To elicit students' understanding of the distinctiveness and validity of different sources of knowledge.* *To elicit students' understanding of the nature and reliability of sources of information*
Worksheet 4 *Students were asked to compare two newspaper articles. While the first article (unfavorable to surrogacy) was written in a more logico-scientific style, the second article (favorable to surrogacy) was written in a more flowery, sensational style, with little evidence, and more rhetoric.*	*To understand how students use evidence in their evaluation of claims.* *Do they evaluate sources of information?Are they sensitive to framing effects? Do they see through rhetoric? Are they ready to confront their biases?*

Table 2: Worksheets used for the study and what they probed

In response to the question (worksheet 1, Q.4) on different ways to find out potential health risks the IVF procedure would cause to the surrogate mothers, all students categorically stated that this is possible by collecting primary (doctor and surrogate mother) and secondary sources of evidence (the Internet). Their views on the reliability and trustworthiness of both sources of evidence were investigated in worksheet 3.

With regard to the primary sources of information, all students recognized that the doctor's knowledge and the surrogate mothers knowledge of the IVF procedure are distinct and valid sources of knowledge. Some students pointed out the limitations and strengths of the two sources of knowledge. There were some who articulated the difference very well as a

distinction between declarative, abstract, generalizable knowledge (expert knowledge) and personal, experiential knowledge (lay knowledge).

Results from the Internet research activity indicate that the criteria that students used when establishing the reliability of a website were naive. One criteria was checking if the information in a website is repeated in other websites. This would conversely establish the reliability of the website as well. According to this criteria, which I term *concurrence*, non-conflicting knowledge regarding health risks posed by surrogacy is available, and it is just a matter of cross checking the information with other websites. Another criteria that a student came up with was *corroboration* – evaluation of the information in terms of whether it is corroborated by one's "real life experiences" - knowledge of the issue that one has gathered on the basis of one's own observations. In case this is absent, then one can talk to a knowledgeable elder that one trusts. Other criteria were *speed*, fast websites being more reliable, as well as the *credibility* of who hosts the website (government or private). Students expressed faith in government websites while they seemed unsure about the reliability of commercial websites.

Students, when evaluating various sources of secondary information, again resorted to naive criteria when evaluating these. One criteria was *popularity*; the belief that the popularity of a particular newspaper makes it reliable. Another criteria was *purpose*; as evident in responses which indicated that information in a medical textbook is reliable because it is designed to help people or that school textbooks have true information because their purpose is to educate. The third criteria was *expertise*, which students employed when discussing the reliability of medical textbooks. Finally, when discussing the reliability of research journals some students used the criteria of *generalizability*, pointing out that the presented research may not be reliable because it might be ongoing or localized to a specific sample or location. Only a few students indicated familiarity with what research journals are. Fig. 4 illustrates the criteria students used when evaluating different sources of information.

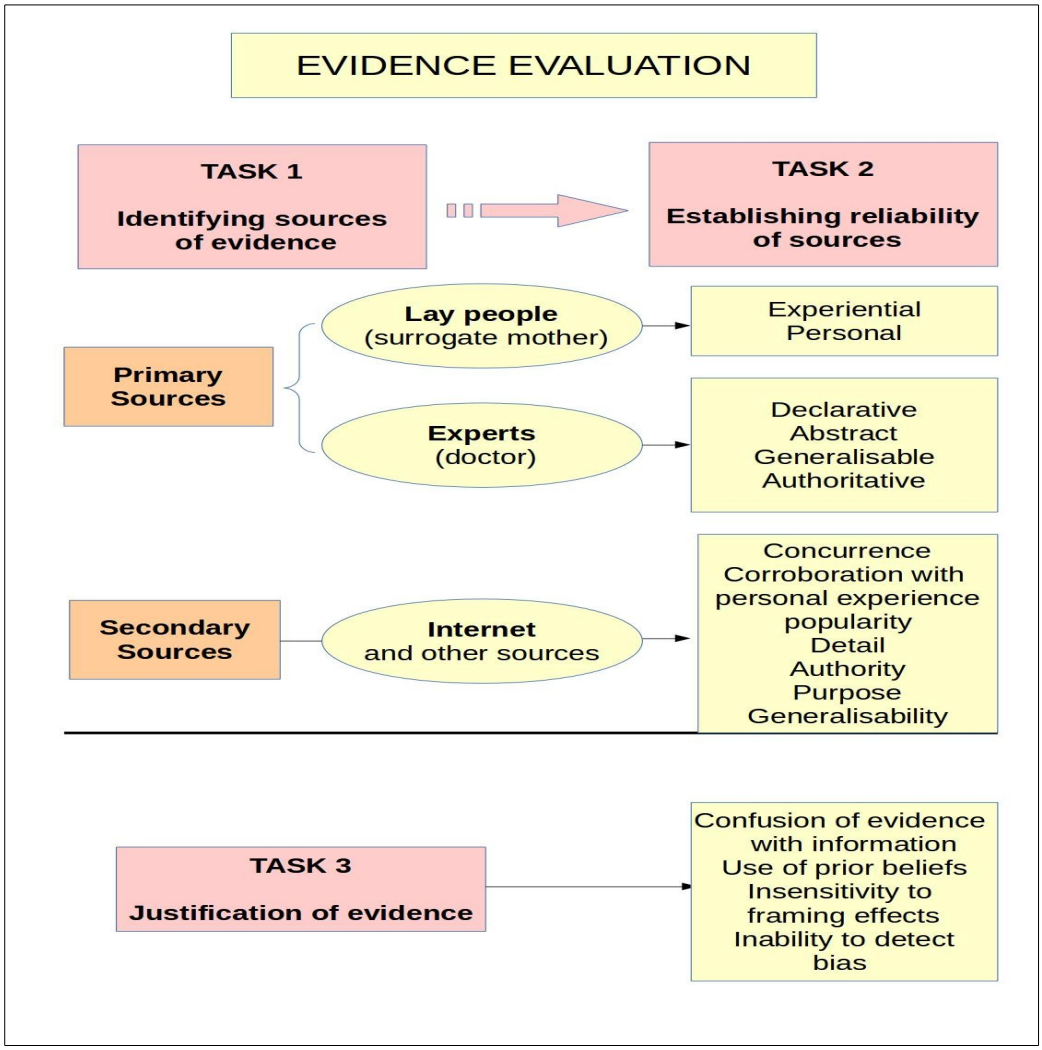

Fig. 4: Criteria raised by students when evaluating sources of evidence

In summary, students showed limited and superficial understanding of how to assess the reliability of different secondary sources of information. While a few students indicated the limited nature of certain sources like newspapers, school textbooks and research journals, as a whole, they did not seem to have a clear idea of how to evaluate different sources of information and what criteria to use when doing so.

The purpose of the final exercise involving the evaluation of two newspaper articles (worksheet 4) was to get students to evaluate the empirical adequacy of the articles, detect bias or vested interests on the part of the authors of the article. While the first article was written more like a research report, the second article was written in an informal manner, using flowery language, with very little evidence. There is also a possibility that the article

was written to promote a fertility clinic.

Regarding the students' abilities to use empirical adequacy as a criteria, some of them (5/10) confused the evidence used in the articles with the information presented, reflecting naive strategies of evaluating evidence. Among students who did indicate some understanding of evidence based evaluation of claims, one student exhibited a strong tendency to go by her own prior beliefs regarding the issue. These findings are consistent with what is reported in Driver, Leach and Millar, (1996) and Zeidler (1997). Even when some students used the criteria of empirical adequacy, they did not appear to consider it necessary if the emotional content of the article appealed to them. Gardner, Jones and Ferzli (2009) discuss *framing* as a way of packaging information by the media to capture the attention of the audience by using specific phrases, words or images. When the frame is weighted towards a certain perspective, through the selective use of certain details, then it is called a framing effect. They point out that frames can have a significant effect on how students engage with issues and cite evidence to suggest that negative frames tend to influence students perspectives more than positive frames. Further, they advocate that students need to develop skills to negotiate media frames that they encounter in order to develop scientific literacy. In this study, however, we find students inclined towards both frames. This may have to do with their prior beliefs and commitments interacting with the framing effect of the article, and requires more research to be established. Indian students have been reported to have positive attitudes towards technology (Khunyakari, Mehrotra, Chunawala & Natarajan, 2009; Sjøberg & Schreiner, 2010). This may have had an effect on their resistance to negative frames in the article. Moreover, the students who were veered towards the second article were all female. These students mentioned being moved by the emotional content of the article which discussed tolerance, sacrifice and will power of the surrogate mother. No generalization can be made from a small sample of students, but future studies could look into whether gender of the reader has any role in how they respond to framing effects.

Literature in personal epistemology postulates that individuals move from views of knowledge as absolute and unchanging, to views that see knowledge as merely personal and subjective, to a more considered and evaluativist position that integrates the objective and subjective dimensions of knowledge. Viewing the results from this framework, one sees some of the participants adopting relativist, subjective positions of evaluating knowledge, considering evidence which conformed to their beliefs regarding the issue, and ignoring

contradicting evidence. Only one student applied an evaluative stand vis-a-vis the articles. He tried to rationalize why the articles may have different positions on surrogacy, though he attributed it to the state of mind of the surrogate mother and how she might have felt at the point of time the interview was conducted. I believe that the student was taking a more sophisticated position when evaluating the articles where he resisted framing effects and tried to understand why there was a contradiction in what is reported in the articles. Besides this, the student justified his allegiance to what is said in one article even after noticing that the evidence is insufficient.

In terms of viewing sources of information as corrupted by interests, only one student pointed out the possibility, in the context of discussing primary sources of evidence, that the doctor's knowledge could reflect vested economic interests. Many students exhibited unquestioning reliance on authoritative expert knowledge, as evident in their responses that were uncritical of doctor's knowledge as well as their view of medical textbooks as carrying true, authoritative knowledge.

Overall, the impression one forms, on the basis of the above discussion, is that higher secondary students' knowledge of how evidence gets collected, theorized about and presented is limited. When given specific activities to evaluate information, some of them do engage with it at a preliminary level. But they do not see how information presented in the media need to be evidence based, how to track the evidence presented in these articles to their sources, and also detect bias and vested interest in the information. The study points to a lack of basic media literacy among higher secondary students and the need to impart skills to evaluate conflicting media reports, synthesize one's own perspective on a controversial topic based on a critical reading of information as well as detect bias, vested interest and so on, which would be necessary skills from the point of view of critical science education.

Chapter 6

Conceptualizing critical science education beyond the school level

While up till now, the focus of the thesis has been on critical science education at the higher secondary level, which represents the 'entry point' to a specialized education in science, this

chapter attempts to conceptualize critical science education for students at the 'endpoint' of a specialized education in science. To this end, I review some work done in India and report findings from a preliminary study with doctoral students (Raveendran & Chunawala, 2015) that explores the value considerations that students employ when evaluating a media article that makes a deterministic claim. Future directions for this kind of work are also discussed.

As mentioned in the introduction, the changing organization of science as well as the concomitant change in the nature of scientific knowledge calls for a different education for those training to be scientists. The new science and technosciences, that have stepped out of the laboratory, and are being produced closer to the context of application[41] (Carter, 2008) are no longer guarded by the Mertonian norms of *communalism*, *universality*, *disinterestedness* and *organized skepticism*. Thus, if we believe in the ideals of socially responsible and environmentally just science, we need reflexive and sensitive scientists who are willing to engage with the public on matters of concern that emerge from developments within science and technology and impact society. Science education will also need to take this challenge head on.

Indian higher education policy and certain initiatives at the higher education level have begun to reflect these concerns. Dhar, Siddiqui and Chandrasekhar (2011), in a discussion of the history of higher education policy in the country point out that the Report of the University Education Commission (1948-49) emphasizes a tripartite division of disciplines on the basis of whether they deal with; facts (Natural Sciences), events (Social Sciences) or values (Humanities) and this compartmentalization continues to rule the understanding of higher education. The report on renovation and rejuvenation of higher education also talks about “cubicalization” of disciplines as being one of the major problems plaguing higher education (Pal, 2009), calling for making disciplinary boundaries porous and for science to concern itself with problems of the real world. Dhar et al., (2011) propose that these priorities need to be operationalized through courses that attempt at “integration” across natural and human science disciplines at the undergraduate level and that the natural science student need to move beyond awareness of social and human issues to an understanding of these disciplines. To facilitate integration, they suggest two models of integration at science education institutes: the soft model and the strong model. While the soft model of integration would

41 Market forces have a huge influence on research in science and technology. Rajan (2006) notes that this is true particularly in the biological sciences where contexts of research have become corporatized.

involve exposing students to courses in humanities and social sciences alongside the courses in natural science in a way that they understand and appreciate the foundations of these disciplines, the strong programme involves getting the disciplines to dialogue in a manner that there is synthesis of new methodologies. To this end, they advocate teaching and research along integrated themes such as cognition, biodiversity and environmental science, biotechnology and bioethics.

Thinking along a more “softer” idea of integration, I believe that instead of introducing students to history, philosophy and sociology of science courses in a decontextualized manner, they should be provided with actual examples within their areas of inquiry which calls into question taken for granted positivist, enlightenment ideals of purity of scientific method and its ability to yield inherent truths about reality. there are plenty of historical as well as contemporary case studies in the sciences that can be used to get students to examine foundational assumptions that go into the construction of scientific claims (Allchin, 2011).

In the area of biological sciences, one such topic is neurogenetic determinism which involve claims that establish links between single gene mutations and complex behaviors which have the possibility of being examined from multiple perspectives: philosophical, ethical and sociopolitical. Genetic determinism refers to the belief system that attributes substantial weight to genes in shaping human traits (Condit, 2007; Lewontin, Rose & Kamin, 1984). This is closely associated with genetic reductionism: the belief that, by understanding human beings at the level of genes or molecules, we can understand what it means to be human. This framework has been criticized for being conceptually flawed. Furthermore, the socio-political ramifications of accepting deterministic claims have been debated widely in philosophical and scientific circles.

In a Nature article titled, “The rise of neurogenetic determinism”, Rose (1995) discussed the epistemic assumptions underlying the faulty sequence of reductive steps employed in constructing deterministic claims in neurogenetics. These include reification, arbitrary agglomeration, improper quantification, belief in statistical normality, spurious localization, misplaced causality, and dichotomous partitioning between genetic and environmental causes (elaborated in the thesis).

Deterministic claims can be criticized not just on the basis of epistemic or foundational (domain general) assumptions, but also on the basis of more “domain specific” research

findings – such as recent research in the fields of neurobiology and developmental biology which has brought forth explanations on the relationship between the genotype and the phenotype which challenge the linear, deterministic model. For every gene, there is a complex and intricate network of regulatory pathways that determine how much protein it produces and at what time. Segments of DNA that are located both near and far away from the gene regulate its activity. These are in turn regulated by proteins produced by other genes, RNA molecules or dietary substances. These findings emphasize that the unit of analysis should not be a single gene but a network of interactions. Therefore, emergent properties in a network, which may not be obvious if we study only a single gene, need to be taken into account in the explanations of genotype-phenotype (G-P) relationship (Berkowitz, 1996). Apart from the conceptual issues delineated above, there is the fact that deterministic claims on behavior are interpreted in a socio-political context and could therefore raise ethical concerns. That is to say "conditions" like homelessness or violence among the poor, which have an obvious social basis and are remediable through social intervention or policy change may get attributed to faulty genes. This may lead to victim blaming or diversion of resources from studies on important environmental and cultural determinants of a trait (Räisänen, Bekkers, Boddington, Sarangi & Clarke, 2006).

Kitcher (2003), in his discussion on political asymmetry, writes, "Standards of evidence must go up when the consequences of being wrong are more serious" (p. 97). In other words, if a certain scientific theory or claim implies support for anti-egalitarian conclusions, the evidence for the former must be strong. Deterministic claims related to behavior, cognitive capabilities and personality could potentially be used to stigmatize already marginalized groups. As per Kitcher's argument, if scientists engage in such research, they would need to apply rigorous standards of empirical adequacy in their work. Hence, there is reason to believe that ethical sensitivity is a necessary quality in a good scientist and should be a part of science education.

A study involving biology doctoral students (reported in detail in Raveendran & Chunawala, 2015) was undertaken to examine how they approached the problem of genetic determinism and the kinds of criteria that they raised when they examined a media article that reported a correlation between a genetic mutation and creativity. Thirty students (20 females and 10 males), who were involved in conducting research in biological sciences in six premiere research institutes in India participated in the study. The students were contacted by email and asked to respond to a questionnaire which involved a newspaper article. The article reported a

study that establishes a link between single gene mutation and creativity.

The study, originally reported in *New Scientist* claimed that a genetic mutation responsible for causing schizophrenia (neuregulin) has also been found to be responsible for creativity and involved genotyping creative individuals (ascertained through certain criteria like filing a patent or writing a book and creativity tests) for the presence of the mutation. The study concluded that people who had two copies of the mutation were on an average more creative than people who had one copy of the mutation and those with a single copy were more creative than ones with no copy of the mutation. The article reported the lead scientist of the research team (Keri) to have said that it should not be assumed that psychosis and creativity are the same. He speculates that it is IQ that probably determines whether a person develops schizophrenia or creativity as clinical experience has revealed that high IQ people are better able to deal with psychotic delusions.

Students employed a wide range of criteria when evaluating the deterministic research claim (Fig. 5). These criteria generated by students are categorized in terms of two values - epistemic and ultimate. The term epistemic values denotes those values that motivate evaluation of the research study in terms of logical and methodological parameters as well as disciplinary knowledge. Ultimate values, introduced by Allchin (1999), describe values that motivate evaluation of the study in terms of utility and consequences--choice of topics of research as well as decisions regarding their ultimate purposes. For instance, extending knowledge of the natural world or developing weapons technology are value-laden goals.

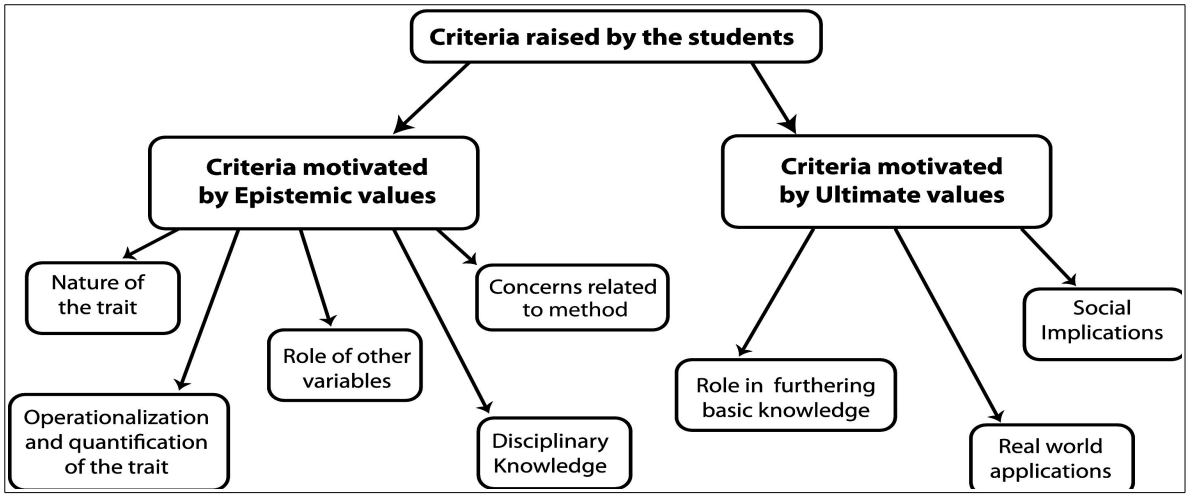

Fig. 5: Criteria raised by the students

Deliberating on the foundational assumptions underpinning deterministic research claims is

an important philosophical exercise. Rose's (1995) step-by-step dissection of the flawed epistemic assumptions underlying neurogenetic determinism is a thorough and well-articulated critique of the assumptions underpinning such research claims. Students who raised basic questions on the nature of creativity, whether it can be defined and measured, or role of other variables indicate an orientation that tries to understand foundational assumptions (Table 3). Although a majority of the students did this, their responses indicated varying levels of insights. For instance, students demonstrating a constructivist understanding of the phenomena (understanding creativity as a construct determined by values) understood the problem of reification. This is further demonstrated by their strong skepticism of measuring creativity. Students who did not demonstrate a constructivist understanding of the phenomena pointed out the difficulty in measuring creativity but did not deliberate on its eventual possibility. The difference in the epistemological positions of students who exhibited a constructivist understanding of creativity and others is an important one - the former were highly skeptical of the assumptions of the study, dismissive about its implications and raised questions on whether the study merited funding. One-third of the students adopted a discipline-based approach in their analysis of the claim. They did not critique the foundational assumptions of the study. What motivated this approach needs further investigation.

I. Nature of creativity (N=19)	Pointed out the complexity of the trait, difficulty in measurement. Were skeptical of defining creativity, some pointed out the socially constructed nature of creativity
Constructivist understanding of creativity (6/19)	*"Creativity is a subjective trait and it could lead to inaccurate estimates...there is a bias in how you define and measure creativity...how could you classify a person as 'uncreative'?"* (P_{12})
Realist understanding of creativity (13/19)	Did not question the existence of the trait per se, but pointed towards difficulty in defining and measuring *"Creativity is a word that covers a broad range of abilities from writing to dance; from singing to painting. The study should have looked at artistes and writers to see if the mutations were indeed seen in individuals from different streams of art"* (P_5).
II. Other variables in the environment that could play a role in creativity (N=8)	Role of factors in the environment (age, gender, nutritional status etc) *"The only measured variables were their 'creativity scores' and whether they carried the neuregulin mutation. What about their backgrounds? Did any of these volunteers have parents who were artists?"*(P_{15})

Students who did not question foundational assumptions of the claim: (N=11)	Did not raise questions on the nature or existence of creativity, but approached it from a purely disciplinary point of view

Table 3: Criteria motivated by epistemic values, domain general criteria

With regard to disciplinary knowledge, we found theoretical knowledge on the Genotype-Phenotype (G-P) relationship wanting in most students. Most references to theory were sketchy and involved elementary knowledge of genetics. Students did not display awareness of the interactionist, developmental coding perspective on genotype to phenotype mapping and of the complex relationship between genes, developmental mechanisms and the environment. There was no mention of the word “development” in any of the student responses. Although some students did talk about the role of the environment in creativity, it was addressed as a variable that needs to be accounted for, by appeal to generic causal logic. Students also used experimental knowledge of their discipline in their critiques. A number of students talked about elucidating signal transduction pathways and carrying out experiments to establish links between the gene and creativity. This is perhaps indicative of the heavily empirical and puzzle-solving nature of biological science research. Working in these paradigms may have influenced students’ responses and attitudes towards the study.

Generating ultimate criteria, in terms of implications and funding when evaluating any scientific study is not an easy task. It requires careful consideration of many factors. As illustrated in the results, a considerable number of these students valued the study for its role in furthering basic knowledge of some sort while some evaluated it on the basis of its applicative potential and sociopolitical implications. These different viewpoints among students are interesting and need further examination. Very few raised potential sociobiological implications of the claim despite criticisms of genetic determinism being a part of public discourse and would be accessible to this group as well. Some dismissed the study for lack of applicative potential, while others naively suggested potential applications in drug design or its potential in removing stigmas against the mentally ill (see Table 4). These responses suggest that students show varying levels of competencies in generation of ultimate criteria as well.

Criteria	Example
Basic knowledge (N=12) Responses focused on the importance of the study in contributing to the repertoire of basic knowledge in discipline.	*"...Most important implication is increase in the understanding of basic phenomena in the workings of brain and their link to behavioral aspects of humans. (This study) provides a starting point of looking at traits like creativity from a purely molecular and objective way"* (P_{20})
Social implications (N=10) Responses discussed ethical and socio-biological implications of genetic determinism as a philosophy.	*What motivates scientific studies, is it merely curiosity? ….when I raised a debate on 'The search for the gay gene' i.e., a genetic basis to explain homosexuality in humans, I was told 'If you don't possess the curiosity to find biological proof for your sexual orientation, you are not a scientist' However, I am not sure if scientific studies are always bias free and thus solely curiosity driven*. (P_7) *"... On the brighter side, it could alter people's view of mental illness pushing them to appreciate its sophistications rather than look at it with predominantly negative and sympathetic mindset" (*P_{27})
Real world applications (N=6) Responses raised questions on practical applications of the research study, for example, drug designing.	*"Research should be oriented at more useful endeavors. There is no good application to this kind of research. If one intends to do pure science then it should at least not have harmful implications to society"* (P_1) *"...looking at the positive side, a psychotic patient can in fact be treated to become more creative"* (P_{19})

Table 4: Criteria motivated by ultimate values

There are several levels of philosophical questions students can grapple with when they evaluate deterministic claims on complex behaviors or qualities, like the following which are based on Longino's (2006) discussion of theoretical pluralism:

1. What is the nature of the behavioral trait? Is it a real trait? If we accept that it's definition is contingent on social and cultural context, can it still be measured?

2. If we accept that the trait can indeed be measured, then how do we define our causal space? What factors do we measure and what do we leave out?

3. What is the nature of knowledge that we have produced? (permanent and certain or partial and provisional?)

4. What are the social implications of the knowledge that we produce?

Discussion of these questions can lead to further explorations in philosophy of science, such as how true are scientific descriptions of the world, the social dimensions of scientific

knowledge, feminist empiricist research on values in science as well as sociopolitical implications of scientific claims. For teachers to be equipped to discuss such issues, they need to be exposed to philosophical literature that discuss values in science as well as develop an understanding of how genetic determinism opens up questions on values and science. For instance, exposure to Longino's (1983, 1987) classical and accessible work, which illustrates how values mediate scientific inferences could be beneficial. Philip Kitcher's (2003) work that discusses the social responsibility of science also might afford insights into the question of what it means to pursue science with a commitment to democratic ideals.

Trends in our data raise questions regarding the cross-disciplinary knowledge possessed by the students — that goes beyond knowledge of one's own discipline — to evaluate deterministic claims. If we take a look at the epistemic criteria that the students generated, we find that only one-fifth of the participants could articulate the problem of reification. Understanding that what is being investigated is an operational definition of creativity determined by value-laden norms requires some exposure to knowledge that is not simply restricted to the discipline of biological sciences. To make sense of this, one needs to ask ontological questions that are philosophical in nature.

From the point of view of critical science education, the fact that only a few students raised concerns regarding the use of the discourse of genetic determinism to support non-egalitarian policies is troubling. Apart from this, straight jacketed disciplinary approaches did not raise questions on the foundational assumptions of the claim, indicating a lack of criticality. The knowledge needed to deliberate on topics like genetic determinism requires the synthesis of scientific as well as non-scientific perspectives that include disciplines like philosophy and sociology. Students with such "cross-disciplinary" (Develaki, 2008) perspectives would not only have knowledge of their own disciplines, but also grounding in other disciplines. Cross-disciplinary perspectives may also contribute to the development of dispositions of criticality towards one's own community. Exposure to the self-reflexive, qualitative paradigms that are gaining ground in the social sciences and humanities, may help develop these dispositions (Dhar et al., 2011).

Chapter 7

Summing up: Reflections and future possibilities

What broad insights does this thesis afford? It charts out a vision for a critical science education in India which centers ideals of social justice and equity. It does so by drawing on and emphasizing perspectives on the nature of science and technology that demonstrate its value-laden nature and the need for social responsibility of science, discusses limitations of the existing curriculum and illustrates ways in which this vision can be realized through the introduction of socioscientific issues at the higher secondary level and discussion of value-laden cases of science at the doctoral level. Through this, it attempts to lay down qualities needed by citizens and scientists alike to determine the course of science and technology that are responsive to the needs of all members of society, upholding the ideas of social and environmental justice.

Fig. 6, though a simplification, attempts to capture significant findings from the different empirical studies reported in the thesis that in turn lays down the basis for critical science education in India. Hodson (2011) characterizes the functions of critical science education in terms of conferring certain epistemic skills, sociopolitical commitments and dispositions (discussed in the Introduction section). The findings from all the studies have been discussed in terms of the characteristics that constitute the epistemic skills and sociopolitical dispositions prescribed by critical science education. The dispositional aspects have not been examined. Study 1, which involved analysis of the class XII biology textbook and curriculum documents demonstrates a lack of careful attention being paid to values, and epistemic skills to critically evaluate information, particularly the risks associated with technosciences. Study 2 shows that when confronting a socioscientific issue, higher secondary biology students espoused value commitments that are inimical to the ideals of social justice. Skills required to critically evaluate information pertaining to the issue were insufficient in many participants. In study 3, which involved work with doctoral students, we find a conspicuous silence among students regarding sociobiological aspects pertaining to genetic determinism, and the adoption of narrow straight jacketed disciplinary approaches to evaluations of the claim.

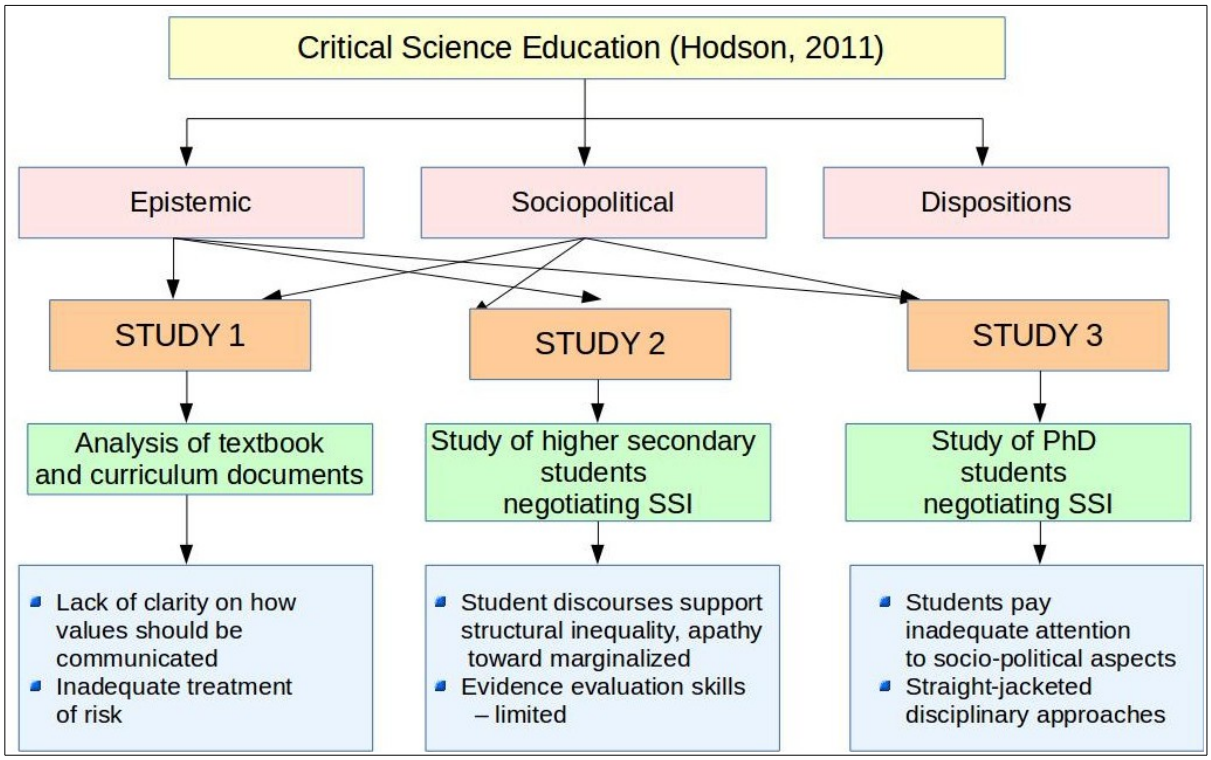

Fig. 6: Significant findings from the studies reported in the thesis

There were specific challenges while conceptualizing and executing this work, two of which are summarized below -

1. Identification of socioscientific issues that were relevant and contemporary:

Identifying issues that were contextually relevant, contentious socially, politically and scientifically, and that would be of interest to students proved to be an arduous task. It required scouring the Internet, newspapers for relevant issues as well as reading and building perspectives on these topics based on academic literature from various disciplines. Besides commercial surrogacy, five other topical, media reported issues related to medical technologies were identified (reported in Raveendran & Chunawala, 2013). Students' negotiation of these issues were also explored. However, this data has not been reported in this thesis.

2. Identifying theoretical frameworks which take into account political nature of these socioscientific controversies:

When one examines socioscientific controversies in the Indian context, the political component inherent in these issues becomes almost impossible to ignore. Developing countries like India are poverty-ridden and pervaded by all forms of social inequalities which

are in turn compounded by the power relations that exist between the global north and south. Varughese (2012), points out that although the overt rhetoric that has captured the public imagination in India equates science and technology with development and progress, technoscience, state and industry are complicit in reinforcing the oppressive structural inequalities (e.g. caste, class, patriarchy). Therefore, these aspects become important to discuss when students engage in a socioscientific controversy.

Many of the existing frameworks which theorize about socioscientific controversies restrict the non-epistemic dimension inherent in these controversies to the moral and the ethical dimension alone, often glossing over the political aspects. If one is focused on inculcating critical scientific literacy, then engaging with the political dimensions of socioscientific issues, and subsequently, cultivating political literacy also becomes important. Levinson (2010) unpacks the notion of science education for democratic participation pointing out how we conceptualize what would constitute SSI education is closely tied up to the notions of democratic participation we believe in. A notion of critical science education would presuppose an understanding of democracy as a pluralist system - a political order where there is struggle and dissent between different ideological viewpoints as opposed to an understanding of democracy as consensus building, which would be presupposed in notions of functional scientific literacy (Zeidler et al., 2005). A major challenge, therefore, has been to identify appropriate theoretical frameworks that can accommodate the political dimensions inherent in these socioscientific controversies. Ralph Levinson's (2006) epistemological framework proved useful as it provides scope to identify the political dimensions as well.

The studies reported are all exploratory and suffer from limitations in terms of the methodologies employed as well as the questions that they seek to answer. Before I conclude, I offer a few directions for future research. My work has only been able to capture, in the form of snapshots, what kind of considerations students bring to bear on socioscientific issues when they first confront them. As Reiss (2010) notes, an “individual’s ethical position on a socioscientific issue will be affected by the individuals around them, the particular scientific or technological issue being considered, their motivation and a range of other factors” (p. 14). It would be worthwhile for future studies to carry out longer interactions with students and try and capture these dynamics as well.

Another important area that requires attention is the development of skills required to evaluate

evidence, particularly in the media regarding various socioscientific controversies. The existing science curriculum does not pay attention to these skills. From the point of view of critical science education, pedagogical challenges on how to tackle rigid, reactionary worldviews that reflect prejudiced notions of caste, patriarchy and other regressive ideologies are also important to address.

Socioscientific issues are a part of the school curriculum in the United Kingdom, North America, Western Europe and Australia (Levinson, 2007). As argued, though the need to bring in the relevance of science to society has been argued for the Indian curriculum, there is no mention of how to infuse it into the curriculum (particularly at the higher secondary level) leaving us with plenty of questions. First, ought it be a necessary part of the science curriculum? Second, if we decide that this should be so, are science teachers equipped to teach these issues? What skills and knowledge would they require to teach these issues? Third, given the context of disciplinary pressures in the existing higher secondary curriculum, how could one introduce these issues in a way that they are not marginalized and treated as inferior to the academic science content that is taught? These concerns have been taken up for more detailed discussion in the thesis.

Indeed, there have been STS courses offered by various universities and institutes at the undergraduate and post-graduate levels (Raina, 2009), but these have not sustained, perhaps due to a lack of an overarching mandate on how STS education should be instituted at these levels. A way forward would be to draw insights from programs like the integrated science education initiative (reported in chapter 6) that afford interesting models on how to expand student sensibilities to accommodate societal concerns and facilitate the production of new kinds of knowledge(s).

Before I conclude, I recall the argument made by Rudolph (2005) and Varughese (2012), that when we talk about the science and the “public”, we cannot forget that the public is not a homogeneous category. This thesis only discusses work with relatively privileged students who constitute a certain sphere of the “public” - the scientific citizen public, who would form members of civil society that the scientific community would engage with. Some of them may, in future, become scientists, engineers, doctors themselves. A large population of children and young adults remain unable to access basic education, leave aside an education in science. How should we conceptualize critical scientific literacy for these sections of

society? This requires serious and dedicated research.

This thesis reflects a certain vision for science education with an explicit commitment to social and environmental justice. When I embarked on my academic journey in science education, I had not imagined that these commitments can also be enacted through science education. Though the explorations reported in the thesis are preliminary, I think their strengths lie in opening up questions - both theoretical and empirical for future work to explore.