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NATURE OF SCIENCE: EMBEDDING SCHOOL SCIENCE IN ITS EPISTEMOLOGICAL PERSPECTIVES

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Nature of science as an educational goal and as an essential component of scientific literacy encompasses explicit development of an informed understanding of the interrelationship between the product and process aspects of science by embedding science teaching and learning in its epistemological bases. Several justifications underpin the spurt in advocacy for inclusion of the 'nature of science' as a cognitive educational outcome and representing the same in a science curriculum. This article presents a synoptic view of the meaning assigned to the term nature of science and henceforth it presents a review of the justifications offered for its inclusion in the science curriculum. Finally, the school science curriculum and the curriculum guidelines for science education at the school level are introspected with the nature of science as an educational goal.

INTRODUCTION

Scientific knowledge along with its practical ramifications in the form of technology has occupied an unprecedented place in the overall history of human civilization and has significantly contributed towards the development of a global culture. UNESCO justifiably emphasizes the development of scientific and technological literacy as is evident in its Project 2000+ Declaration. The significance of science and technological literacy is unanimously acknowledged with the wider social reverberations of the same in the present scenario (Jenkins, 1994). The phenomenal change eventually justifies the concern for achieving some level of understanding of science by the citizenry.

Scientific literacy (SL) has in the recent decades emerged as the primary goal of science education under the auspices of the contemporary reform movement advocating science education for every child (AAAS, 1993; Lee, 97) within a social and cultural context of the child and widespread acceptance of constructivist learning paradigm (AAAS, 93; Staver, 1998) with an overall aim to diffuse SL among all individuals.

SCIENTIFIC LITERACY AND NATURE OF SCIENCE

SL is a widely acknowledged educational goal and at the same time it is also considered as a contested term. Laugksch (2000) claimed that there are different interest groups related to the concept of scientific literacy that interpret the meaning of the term in accordance with their specific interests and purposes. Laugksch classifies the definitions of scientific literacy into three broad categories. The first category

includes definitions that justify SL for the intellectual value associated with the term and highlights the significance of SL for its own intellectual sake rather than some instrumental purpose. SL is also defined in terms of the acquisition of certain context-free basic skills that help them understand science and its methods. Finally, SL is defined in terms of the application of the knowledge and skills in science in the social context and hence bringing in a humanistic perspective in the conceptualization of scientific literacy. The usefulness of being scientifically literate in a different social and cultural arena of life is the guiding perspective of those affiliated to this category. The third perspective on the meaning of SL is used as the general context for discussions about the Nature of Science (NOS).

The social and cultural perspective on defining SL is considered as instrumental in everyday decision-making situations of everyday social life particularly those related to science (National Research Council, 1996). NRC (1996) interprets SL as the minimum understanding required for "personal decision making, participation in civic and cultural affairs and economic productivity" (p.22). Such decision making capabilities are considered as the core of democratic citizenship. Adopting a similar perspective, OECD/PISA defined scientific literacy as "...the capacity to use scientific knowledge, to identify questions and to draw evidence based conclusions to understand and make decisions about the natural world and the changes made to it through human activity" (Gilbert, 2004, p.40). Thus SL is conceptually linked with education for a democratic citizenship.

The social and cultural perspective of SL is a multidimensional concept and it includes Nature of Science (NOS) as one of its essential components beside understanding the content in science and the processes of science. NOS refers to the set of values, assumptions and limitations regarding the scientific knowledge and scientific processes and hence is conceptually linked to the epistemology of science. Attainment of the goal of scientific literacy is then, an outcome of the concerted interaction of the three aspects of science education in the school science experiences. All three aspects are equally important in any curricula of science education that aims to foster scientific literacy among the students.

UNDERSTANDING NATURE OF SCIENCE

NOS is a common phrase used by the science educators' community as a description of the characteristics of science and hence is conceptually related to the philosophy of science in general and more specifically with the epistemology of science, even though the sociologists of science, historians of science and the scientists also have their interests in NOS (Mc Comas. 1998). A common issue transcending across all the interest groups is the conception of the epistemological underpinnings of science- the basic premises that justifies and validates scientific knowledge. With respect to the epistemological base of science, there exists at least two different positions viz. the ontological position of realism and that of anti-realism. The realists conceive nature as having an independent existence with respect to human perceptions and that such independent reality can be cognized in an absolute sense through the methods of science. The science curricula therefore ought to reflect this objective and empirical characteristic of science.

However it is the representation of science in school curriculum that has been questioned in light of the

epistemological underpinnings of science. The traditional science curricula represent scientific knowledge as an exact description of things as they exists in reality that was made known by the disinterested and objective outlook of the scientists who provide conclusive verifications of their ideas through direct observation of nature aided by experimentation. Such science curriculum is grossly misrepresented. Von Glasersfeld (1995) claimed that the realists stand on the truthfulness of reality cannot be logically established as "the truth of any particular piece of knowledge" need comparison with that which is being known which again is logically not possible as it will involve yet 'another act of knowing"(p.6).

The criticism raised against naïve realism caused the alternative epistemological perspective gained currency (Leach, et., al., 1996). The alternative perspective on NOS that emerged and gained importance is commonly termed as the constructivist perspective with an instrumentalist ontology (Matthews, 1998). Constructivist perspective is fundamentally an empiricist in its approach (Staver, 1998) as knowledge is not a simple matter of discovery and verification and rather it is a matter of construction wherein an individual engaged in cognition tries to make out a sense of his sensory impressions. Thus, there exists overlap between the different stands on the NOS. The constructivist perspective on NOS then advocates for a different stand on representation of NOS in science curriculum.

It is owing to the degree of sophistication involved in discussions centered on NOS and the complexity involved therein, that many consider NOS as inaccessible for the school level students and hence make it devoid of its educational sheen (Abd-El-Khallick et al, 1998). However, the contention regarding NOS are basically related to the issues related to ontological positions vis a vis science. However, there are common grounds as well that provide promising prospects for NOS as an educational outcomes. The consensus view that emerged on the NOS is considered as all - philosophers, historians of science, scientists and science educators (Mc Comas, 1998). For example, Matthews (1998) draws the common ground between realists and constructivists and highlights that both acknowledge the changing nature of scientific theories, based on empirical evidences and the research agenda of the scientists are socially and culturally influenced. The existence of common grounds unambiguously makes teaching and learning of Nature of Science feasible and practical.

NATURE OF SCIENCE: CONSENSUS VIEW

Researchers have tried to arrive at a consensus view on NOS that is the best compromise of the different positions held by the philosophers' with respect to NOS and that is relevant for the young students (Bell et al, 2003). NOS is defined in a pedagogically relevant way as the "*values and underlying assumptions …intrinsic to scientific knowledge including the influences and limitations that result from science as a human endeavor* (Schwartz et al 2004, p611). This definition of NOS is pedagogically represented in form of a set of agreed upon 'tenets' (Efflin, et.al., 1999) and enable comprehending science as a body of knowledge as well as a process to arrive at the knowledge (NRC, 1996; Duschl et.al., 1990; Hodson, 1998; Aikenhead & Ryan, 1992). These tenets are listed as below: Science is an attempt to explain natural phenomena; Scientific knowledge is obtained through scientific inquiry that includes both observation and inference; Observations are basically theory laden i.e. what is observed and how it is to be observed is guided by the scientists' theory/

hypotheses; Inferences drawn from the verifiable data is subjective in nature and there are possibilities of disagreement among scientists; Science yields knowledge that is verifiable being justified by observation, experimental evidence, rational arguments and skepticism; The nature of observation and inference in scientific process explains role of creativity in science; Laws and Theories, as the product of science, are related but different from each other and serve different roles in science; Scientific Knowledge while durable has a tentative character. Science has a social and cultural dimension; Science and technology are interrelated but not the same (McComas, 1998; NRC, 1996; Abd-El-Khallick, 1998).

NOS AND CURRICULAR SHIFT

Nature of science is a vital learning outcome that establishes the link between science content knowledge and the processes of science. Advocacy for NOS as an educational outcome has sound theoretical and practical bases. NOS is also construed as the epistemological beliefs (EB) in context of scientific knowledge, where epistemological beliefs relates to what one believes regarding the nature of knowledge and its development (Hofer and Pintrich, 1997) that has been established to be developed among young adolescents as well (Schommer,1993). Further, studies have established that sophistication of the epistemological beliefs is related to the way one processes information and the value one places on that knowledge (Hofer and Pintrich, 1997; Perry, 1970; Carey et al, 1989). NOS being science epistemological beliefs, influences one's way of processing scientific knowledge and applying it in different contexts (Songer & Linn, 1991; Staver, 1998). It also influences one's orientation towards learning of science (Songer and Linn, 1991; Lederman, 1992; Tsai, 1998), enhance students' interest in science (Mc.Comas, 1998) and assist them in reflecting on knowledge content (Larochelle and Desautels, 1991). The way in which students understand NOS influences their conceptual understanding of science content knowledge (Songer and Linn, 1991; Staver, 1998) and reflecting on knowledge content (Larochelle and Desautels, 1991).

Further, understanding of NOS is essential to understand the way scientific knowledge is created along with its limitations. Such an understanding is deemed essential for democratic participation of citizens in social issues particularly those related to science. The ever increasing nexus between social issues and their conceptual link with science and technology is an indication of the even greater significance that will be gained by the concept of NOS. Shamos (1995), while qualifying the importance of NOS, emphasized on defining scientific literacy overwhelmingly in terms of understanding of NOS rather than in terms of content knowledge (quoted by Laugksch, 2000). Millar and Osborn (1998), in their important document *Beyond 2000,* maintains that for a majority of students who are future citizens in different roles rather than future scientists, the core school science curriculum should be one that focuses on *knowledge about* science rather than *knowledge in* science where knowledge about science exclusively includes an understanding of NOS. Thus, *science for citizenship* aims at developing the citizens' capabilities to actively participate in debates and discussions related to such socio-scientific issues (AAS, 1989, Driver et al, 1996, Jenkins, 1999). However, the extent of participation and the quality of decision in such issues depend on the individuals' understanding of the scientific enterprise (Kang et al, 2004; Sadler, 2004) thereby substantiating the salience of NOS to citizenship education.

Summarily it can be claimed that NOS is pedagogically represented as set of cognitive learning outcomes that need to be provided proper representation in science curriculum at the school level. As the cultural context provides the necessary tools for the individuals in the meaning making process (Vygotsky, 1962), the norms and values of science as a culture need to be exhibited before the students (Driver, 1994, p.6).

Almost all the major curricular reforms in the second half of the twentieth century held the Armstrong's assumption that the students will understand the NOS through different science process skills, science content knowledge and scientific inquiry. The major curricular reforms such as Biological Science Curriculum Studies (BSCS), Nuffield Physics, and Physical Science Curriculum Studies (PSCS) laid a greater emphasis on the process aspect of science with the assumption that it will help students learn the true NOS.

However, the implicit approach to develop NOS among students came under severe criticism by the dawn of the twentieth century giving way to more vocal arguments in favor of teaching NOS in an explicit way. Millar and Driver (1987) highlighted the myth of dichotomous view on NOS as content and process and concluded that both the content and the processes of science are intertwined and interdependent for the learners. The study related to NOS and BSCS gave a severe blow to this basic assumption when it was concluded that even a science curriculum with emphasis on the process aspect of science like BSCS failed to develop informed understanding of NOS among the students (Meichtry, 1992) that further supported similar views presented earlier (Lederman, 1992; Abd-El-Khallick & Lederman, 2000).

Currently, diverse contexts are being explored to provide overt teaching and learning of NOS. Scientific Inquiry is still the most favorable and popular context, however in a different form with more emphasis on students active engagement stimulating their thought processes, explored by the researchers for developing informed understanding of NOS (Bianchini & Colburn,2000; Schwartz, et., al., 2001). Historical development of scientific knowledge is also researched for its efficacy in explicitly teaching the NOS principles and has been reported to be a suitable pedagogical approach (Abd-el-Khallick, 1998). Recently, socio-scientific issues are being explored as a pedagogical innovation for explicit discussion on assumptions of science (Sadler, et., al., 2004). Finally, modification in the science text books are also recommended to include overtly expressed section on NOS (McComas, 2003).

NATURE OF SCIENCE AND SCIENCE CURRICULUM: REFLECTIONS ON INDIAN CONTEXT

A brief but relevant understanding of NOS is acknowledged by the curriculum frameworks in Indian context (NCF, 2005) that in turn reflects the emphasis laid on including instructions pertaining to NOS earlier in the academic career (Kang, et. al., 2004). It is justifiably claimed that the link between the science content, science processes and NOS must be overtly made apparent by the teachers and that the "assessment of student`s prior knowledge" related to NOS must be used in the curriculum development (Meichtry, 1992, p. 405). NCERT (1998) in its National Curriculum Guidelines of Syllabus has identified NOS a long back as one of the seven dimensions of science curriculum that was again reiterated NCF (2005). It explicitly states that "Good Science Education is true to child, true to life and true to science" (NCF, 2005,

p.46). Science curriculum can be true to science if it presents a true image of science in the classroom and true to 'life` if the image thus created in the classroom enable the individual, to apply and use that knowledge in real life context including the socio-cultural context.

Unfortunately, the pedagogical approaches to NOS are missing from these documents that reflect their implicit approach towards this educational goal. A closer inspection of the curriculum documents reflect that the pedagogical approach lingers around the process or inquiry approach that unfortunately has yet to be translated into effective classroom practices. It will not be an exaggeration to claim that the curricular approach in vogue for science education is apt to exclude the attainment of vital components of scientific literacy.

The curricular documents grossly failed to explicate exactly what is to be understood by NOS and how to incorporate the same in classroom teaching and learning (Rai, 2009). The scenario raises skepticism with respect to achievement of the goals of NOS. The spurt in advocacy for curricular and instructional modifications with the aim to develop informed understanding of NOS among the students, observed across several nations, should find a place in the concerns of the curriculum policy framers and science educators along with exploration of the innovations (as mentioned in the previous section) in the Indian context. Empirical studies related to NOS could be broadly classified into five categories or encompassing five different themes viz. those related to students' conceptions of the NOS; teachers' conception of NOS; assessment of NOS and interventions; relationships between teachers' conceptions of NOS, classroom practice, and students conception of NOS; and development and validation of instruments for assessment of NOS (Lederman, 1992). Studies are needed in each of these areas as well as a rich empirical database on students' existing framework of knowledge regarding NOS (Kang, Scharmann, & Noh, 2004) is direly needed in the Indian context.

The ambiguity with respect to teaching and learning of NOS in the curriculum frameworks developed from time to time, paucity of empirical studies related to understanding of NOS by the school going students and the instructional strategies related to teaching and learning of the same, neglect of the different principles of NOS in the reputed science text books together manifests the need to rethink about the status of school science vis-à-vis international trend.

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ETHICS AND SCIENCE EDUCATION IN A WICKED WORLD

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Wicked socioecological issues pose challenging ethical dilemmas related to both human and nonhuman life on this planet. This paper makes the case that science education must enable students to understand environmental issues not just in terms of science content but also from appropriate ethical standpoints. Some ethical frameworks for understanding environmental issues have been proposed in the field of science and environmental education. However, these ethical frameworks were developed in an era in which technology seemed to power limitless economic growth, environmental sustainability was not considered mutually exclusive with such growth, and we had not yet entered the new age of unprecedented ecological catastrophes. In this paper, therefore, I also make the plea for a critical examination of the relevance of the current ethical frameworks for informing the role of science education in the new Anthropocene epoch.

INTRODUCTION

The latest report of the Intergovernmental Panel on Climate Change (IPCC, 2018) makes it abundantly clear that unless prompt, far-reaching, and unparalleled changes are undertaken to transform the relationship humans have with the rest of the world, our planet is headed for a catastrophic future much earlier than expected. I believe that science education has an important role to play in preparing future citizens to mitigate and cope with the disastrous effects of climate change and other environmental crises of the Anthropocene epoch; crises that our current generation of leadership have utterly failed to address. This paper makes the case that an important step in this direction would be to enable students to understand environmental issues not just in terms of science content but also and equally importantly from appropriate ethical standpoints. As I argue in this paper this is because environmental issues are quintessential *wicked problems*, which are "defined by high complexity, uncertainty, and contested social values" (Miller, 2003, p. 279). Thus, environmental issues pose challenging ethical dilemmas related to both human and nonhuman life on this planet with profound justice and equity implications of environmental problems for poor and marginalized people. Though we see promising efforts in the United Kingdom, New Zealand a few other countries, unfortunately, in the rest of the world there currently appears to be little movement towards inclusion of ethics as a component in the intended official science curricula (Reiss, 2008; Jones, et. al, 2007).

Of course, this is not to say that official science curricula are devoid of implicit or explicit ethical dimensions. But research (Bazzul, 2016; Sharma & Buxton, 2018) appears to indicate that the ethical standpoints tacitly implicated in the intended and enacted science curricula hinder rather than help students both in understand-

ing and in taking ethically just actions towards ameliorating environmental problems. Some ethical frameworks have been proposed in the field of environmental ethics and environmental education for understanding environmental issues from an ethical standpoint (Palmer, 2013; Saunders and Rennie, 2013). Most of these ethical frameworks were developed in an era where technology powered limitless economic growth and environmental sustainability were not considered mutually exclusive (WCED, 1987). Therefore, in this paper I assert that it is important to (a) critically examine the relevance of these ethical frameworks in the current Anthropocene epoch, and (b) explore the meta-ethical foundations of alternative ethical frameworks that might be better suited for inclusion as components of science education for this new era of unprecedented wicked environmental problems. I believe that this examination is an important step toward the development of the philosophical foundations of ethical reasoning that needs to become a critical part of science education in the current era of ecological catastrophes.

THE WICKED ETHICAL DILEMMAS OF ENVIRONMENTAL ISSUES

Ethics is about answering the question: "What is the right thing to do"? Unfortunately, we live in an extremely complex and interconnected world where it is often not easy to decide what is the right thing to do, especially regarding socioecological issues. Let me illustrate this challenge with an example from the United States, where I currently live and work. Imagine that a student in the United States learns in her science classroom one day that bananas, the most consumed fruit in the United States, come from plantations that have caused massive destruction of rainforests in South and Central America (Clay, 2013). This student may decide that a boycott of bananas would be an ethical response to save rainforests from these plantations. In fact, many mainstream environmental groups, such as *Rainforest Relief*, do urge customers to "avoid purchasing bananas altogether and instead opt for fruit grown locally, such as apples, peaches, cherries or pears" ("Banana Industry's Impact on Rainforests", 2010). Alternately, some environmental groups, *Rainforest Trust* for example, may try to save rainforests by buying land in these regions so that they can be restored to their pristine ecological health (Butler, 2014). But as Vandermeer and Perfecto (2005) explain such actions alone may hurt the rainforests more than save them. The closure of banana plantations can result in loss of jobs for many plantation workers who often end up converting forests into subsistence farmlands in order to survive.

This student may instead decide that buying organic bananas might be the best option to help save the rain forests. However, the world currently is not in a position to feed all the people on the planet through organic farming (Seufert, Ramankutty & Foley, 2012). Organic bananas can be grown in only very specific conditions that severely limits the amount of land available for growing them. So even if there was a 10% percent drop in supply of regular bananas, the potential of growing organic bananas will not be able to meet the demand (Loza, 2016). The cost of production for organic bananas is much higher too. So, if only organically grown bananas were available in the grocery stores, it could mean that bananas would go back to being the exotic fruit for the rich like they were back in the 19th century. Again, higher prices may decrease demand, laying off plantation workers who return to unsustainable subsistence farming practices. Similar outcomes may result if our student adopts the strategy of raising money to buy up land for conservation and restoration. This is not likely to work either and may only lead to an ecological landscape marked by "isolated islands of

tropical rain forest surrounded by a sea of pesticide-drenched modern agriculture, underpaid rural workers, and masses of landless peasants looking for some way to support their families" (Vandermeer & Perfecto, 2005, p. 13).

A seemingly simple question of whether to consume or boycott bananas ends up revealing a complex global assemblage of relations and entanglements involving local and distant human, non-human, material, social and cultural actors, and ethical-political dimensions. Simple actions such as a product boycott can indeed be counterproductive in resolving environmental issues because when we affect one strand of the complex web of causality inherent in these assemblages, the effects reverberate through the web in unanticipated ways to yield all kinds of desirable and undesirable outcomes. Thus, we find that an issue that on the surface looks very simple when unraveled reveals serious ethical quandaries that deserve to be acknowledged and tackled. This turns out to be the case for most environmental issues. Unsurprisingly, therefore, researchers have come to recognize environmental issues as a classic example of wicked problems (Brown, 2001; Camilus, 2008). Socioecological problems are wicked because they are "defined by high complexity, uncertainty, and contested social values" (Miller, 2013, p. 279). They arise from "the functioning and evolution of interconnected and complexly interacting socio-ecological systems" and defy solutions because "they are multicausal, intertwined with other problems, and value-laden" (Metzger & Curren, 2017, p. 94). As a result, environmental issues pose such difficult ethical dilemmas that unless one is equipped with appropriate ethical frameworks it becomes very hard to answer the question "what is the right thing to do?"

Unfortunately, wicked socioecological problems define our existence in the Anthropocene epoch, the geologic time period in which humans now substantially alter the Earth's geology and ecosystems. These challenges have long been known to affect the poor and marginalized sections of society disproportionately, and their impact on nonhuman life has been nothing short of disastrous (Walker, 2012). Any attempts to resolve such problems are also likely to create additional complex equity and socioecological justice implications for all kinds of life on this planet. As a result, as we saw in the examples above ethical dimensions are critical for both understanding and acting upon socioecological challenges (Brown, 2001).

ETHICAL LITERACY: WHAT DOES IT HAVE TO DO WITH SCIENCE EDUCATION?

Therefore, if we wish to remain hopeful about our future, we need to prepare our students as citizens who not only understand the 'wicked' nature of socioecological issues facing our planet but who are also deeply cognizant of the ethical implications of action as well as inaction on these challenges. Unfortunately, research (Sharma & Buxton, 2018) indicates that the implicit ethical stance in the school science curricula in the United States is problematic on several counts. Based on my past association with the Hoshangabad Science Teaching Program in Madhya Pradesh in the nineties and continued collaboration in science curriculum work with erstwhile colleagues in Eklavya in Bhopal and Hoshangabad, I am not sure if the situation is any better in India. In the United States for instance, school science curricula typically exhibit a strong belief in human exceptionalism. This view partitions the world into distinct social and natural domains, with human concerns at the center and issues related to nonhuman existence and survival at the periphery in deliberations on issues of resource allocation, survival and sustainability. This ethical stance is predicated on instrumental reasoning

that, in concert with human exceptionalism, supports the commodification of the nonhuman aspects of our world. Research also shows that the ethical standpoint embedded in science curricula is neither explicitly articulated nor challenged in the science classrooms, thereby facilitating its uncritical reception by the students (Bazzul, 2016; Sharma & Buxton, 2018). In agreement with Poole et al. (2013) I find the absence of ethical learning to be "particularly problematic regarding environmental issues as management decisions must integrate ecological, social, and cultural dimensions, and a comprehension of the values underlying those decisions" (p. 349). It is hardly surprising, then, that when young adults in the United States are quizzed on the ethical implications of climate change, a clear majority is either unsure or does not see climate change as representing any moral or ethical issues (Markowitz, 2012).

It is therefore imperative that instruction on ethical implications becomes an explicit and critical component of science education not just in the United States and India, but in all nations of the world. Unfortunately, a number of powerful factors continue to frustrate inclusion of ethics in science education, including the naïve belief in value-free science, fears of indoctrination and relativism if ethics become part of school curricula, and the hegemony of neoliberal logic that insists on transmuting all non-economic and social values into economic values (Poole et al., 2013). However, in recent years, a strong case for inclusion of ethics in science curricula has been made by several science educators from different parts of the world (Reiss, 1999, 2011; Zeidler and Sadler, 2008). These calls for including ethics in science education have been made on the grounds of better understanding the nature of science, improvements in the ethical sensitivity, knowledge and judgement of students, and broadening participation of students who might otherwise show limited interest towards science learning. Science educators and researchers engaged in research and instruction on socio-scientific Issues in science education in particular have been a redoubtable votary of the inclusion of moral and ethical issues as critical components of scientific literacy (Sadler, 2004; Saunders and Rennie, 2013; Zeidler and Keefer, 2003).

CURRENT ETHICAL FRAMEWORKS IN SCIENCE EDUCATION

As things stand there is no dominant or preferred ethical framework in science and environmental education for instruction on environmental or socioscientific issues. Usually, proponents of inclusion of ethical literacy make the case for viewing scientific and environmental issues from a few dominant perspectives that constitute the scholarly canon on ethics in western societies (Reiss, 2003; Zeidler and Sadler, 2008; Beauchamp and Childress, 2001). Though these scholars articulate their frameworks differently, broadly speaking the different ethical frameworks articulated by them can be clubbed under *consequentialism*, *deontology* and *virtue ethics*.

Consequentialism: Ethical theories categorized under consequentialism make the case that only the consequences determine whether an action is ethically right or wrong. That is, if we wish to be ethical we should aim to bring about best outcomes. (Brennan and Lo, 2002).

Deontology: In contrast, deontological ethical theories maintain that it is in the context of our moral rules and duties that we decide what is the ethical thing to do. According to Palmer (2013), "Deontological theories

in environmental ethics emphasize rules, principles, duties, rights or some combination of these. The basic idea is that we should adopt certain principles or respect certain rights, rather than that we are required always to maximize the good" (p. 199).

Virtue Ethics: In distinction with both consequentialism and deontology, virtue ethics conceptualizes ethical action in terms of virtues, like "kindness", "honesty", "sincerity" and "justice" (Brennan and Lo, 2002). In an environmental context, therefore, virtue ethics centers on "our attitudes and dispositions with respect to the environment" (Palmer, 2013 p. 200).

Unfortunately, indigenous and nonwestern ethical perspectives find themselves on the margins of scholarly conversations on ethical literacy in science and environmental education. Though, it is encouraging to note that a few scholars have argued for ethics of caring or feminist care ethics as important for inclusion in science education, or have advocated for pluralism in recognizing diverse ethical standpoints and values of different social groups (Lloro-Bidart, and Semenko, 2017; Reiss, 2003; Saunders and Rennie, 2013).

The ethical frameworks that dominate the conversation for inclusion of ethical literacy in science education are mostly the products of the age of enlightenment and modernity in the western world. They have been critiqued by environmental ethics scholars on theoretical grounds as well as for being out-of-step with the realities of life in the Anthropocene on several grounds. the main critiques of these modernist ethical frameworks can be summarized as follows:

1. They are based on a strong belief in human exceptionalism that leads students to partition the world in two distinct social and natural realms. This belief positions human concerns at the center and issues related to nonhuman existence and survival at the periphery (Sharma and Buxton, 2018).
2. Humans are reified as autonomous, rational, responsibilized individuals who can freely exercise their ethical agency independent of the socio-material context. Further, in any consideration of the situatedness of human ethical action, the environmental, nonhuman world is simply treated as a passive background (Whatmore, 1997).
3. Modernist ethical frameworks adhere to a material essentialism that characterizes the entities in the world with "a set of immutable properties that are relatively or absolutely autonomous from those of other entities and relatively enduring" (Castree, 2003, p. 4). Environmental ethicists are increasingly considering this material essentialism as untenable in the Anthropocene epoch that teems with "myriad part-human, part-organic, part-machinic entities that resist being represented within the conventional *taxon*", and owe their ontological properties to the varied discursive-material networks they are embedded in (Castree, 2003, p. 8).
4. These frameworks are anthropocentric in that they assume "capacity for reason as the definitive basis of a distinctively human ethical standing" (Whatmore, 1997, p. 38). This elevates the moral significance of humans vis-à-vis the nonhuman world, and serves to deprive the nonhuman world, such as birds, animals and trees, of an independent *ethical standing*, and visibility in any ethical calculus based on these frameworks (Valentine, 2004).

5. By consigning ethical consideration to instrumental logic (consequentialism), individual rights and responsibilities (deontology) and personal virtues (virtue ethics), these ethical frameworks work to depoliticize environmental ethical dilemmas. This depoliticization severely impoverishes the public sphere and diminishes the much-needed space for democratic contestation and decision-making on wicked environmental issues (Douglas, 2018).

In a way, therefore, these modernists ethical frameworks align well with the *Dominant Social Paradigm* of our times that has valorized low evaluation of the natural world for its own sake, compassion mainly for those near and dear, limitless economic growth and maximization of wealth, and instrumental, technocratic rationality (Harper and Snowden, 2017). It is hardly surprising, therefore, that the dominant pro-environment ideology continues to be *environmentalism*, which promotes the understanding that environmental dangers to the planet can be tackled within the existing political, economic and cultural order (Harrison and Boyd, 2018).

CONCLUSION

It is high time that we clearly recognize that we are in a new age of unprecedented ecological catastrophes. The scale of these crises has made it quite impossible to be confident about the planet's future without sounding naïve and out-of-touch. According to the newest report of the Intergovernmental Panel on Climate Change (IPCC, 2018) we only have a little more than a decade to undertake rapid and far-reaching transitions in our socioeconomic and industrial systems to limit the global mean temperature rise to 1.5^0C. That is, we have scarcely any time left to undertake actions designed to partially mitigate the impending threat to all life on earth. This is especially true for disadvantaged and vulnerable populations, including indigenous people and communities in poorer parts of the world, who are dependent upon agriculture or coastal livelihoods. As the already existing robust critique of modernist ethical frameworks indicates, it is quite likely that in the coming dystopian age in which "business as usual" approaches to science education as well as education in general might not work, we may need more radical ethical frameworks to guide our intended and enacted science curricula in schools all over the world (Sharma & Buxton, 2018; Whatmore, 1997). In addition to indigenous and feminist ethical perspectives, there are a range of ethical standpoints that have been proposed in response to the call for alternative frameworks that are immune from the aforementioned critiques of modernist frameworks. At one end we find frameworks like *non-centered democratic ecologism* that discards the nature-social dualism and encourages us to see the world as consisting of networks of nature-culture collectives (Latour, 2012). In these nature-culture collectives, non-humans are no longer relegated as objects with no ethical standing. Instead, they are included as constituent members of the social with the understanding that we extend equivalent (if not equal) ethical obligations to them as accorded to humans (Whatmore, 1997). At the other end, there exist standpoints like *post-environmentalism* that argues that we need not place any limits on economic activity to save our planet. We just need to unleash human creativity and ingenuity to find technological solutions for current environmental crises (Shellenberger and Nordhaus, 2011).

Unfortunately, however, there has been little discussion among science educators and researchers on the appropriate ethical frameworks for ethical literacy as part of K-12 science instruction. The only progress we

have had so far is a recognition amongst a small group spread across different parts of the world that students need ethical literacy in order to better understand and be agential about socioscientific issues in science education. That is not enough. It is critically important that more members of the international science education community join this conversation by (a) recognizing the need to include ethical literacy as a part of science education; and (b) examining the philosophical foundations of current as well as alternative ethical frameworks to assess their adequacy for informing the role of science education in the new Anthropocene epoch. In the United States and a few other nations this conversation has already begun. It is my hope and plea that science educators in India too heed the call of the global socioecological moment we currently find ourselves in.

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"ASIBIZI": TEACHING HUMAN REPRODUCTION IN RURAL EASTERN CAPE SCHOOLS

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The primary focus of this paper is to explore the possible influence of cultural taboos when teaching human reproduction content knowledge by isiXhosa speaking teachers in rural secondary schools of the Eastern Cape, South Africa. Previous studies on Xhosa culture and the teaching of science have focused on the inclusion of indigenous knowledge in the curriculum, citing the need for cultural restoration and heritage. However, little research has focused on the experiences of rural teachers when teaching sexually related content to teenage learners of the same ethnic culture where traditional ways of behaviour are compelling within an ethnic grouping. In this paper, we used semi-structured qualitative questionnaires to explore the views of twenty-nine rural secondary school Life Sciences (Biology) teachers and one Life Sciences Education Specialist on the possibility of cultural taboos in terms of restricting language use when teaching human reproduction. Cultural taboo themes and examples of 'language conflict' were generated via thematic analysis of the data. The term 'language conflict' is taken from the isiXhosa word 'asibizi', which means, 'we do not talk about this'. The claim that is made is that cultural taboos embedded in cultural beliefs of Xhosa-speaking communities may be regarded as a fifth language issue that restricts the teaching of Life Sciences concepts of a sexual nature in terms of language and lexicon use; namely what teachers are allowed to say and the words that they are allowed to use.

Keywords: Teaching human reproduction, Xhosa cultural taboos, Fifth language, Rural secondary schools, South Africa.

INTRODUCTION

Research indicates that talking about sexually related content can be culturally offensive to certain groups worldwide (Buni, 2013; Kral & Schwab, 2012). This view is prevalent in Sub-Saharan African countries (Doidge & Lelliott, 2016; Mhakure & Otulaja, 2017). The question posed in this paper is whether the belief in cultural offensiveness is pervasive among indigenous Xhosa people living in traditional, rural villages of the Eastern Cape. Specifically, we explore Xhosa teachers' beliefs about how the cultural belief of *'asibizi' - 'we do not talk about this'* – may impede the use of standard, academic language required for teaching human reproduction as prescribed in the Life Sciences curriculum (Dube & Lubben, 2011; Odora Hoppers, 2009).

Webb (2013) explored whether a culturally homogenous group such as the Xhosa people of the Eastern Cape share a common understanding of their indigenous knowledge (IK) and whether they see any value in

including their cultural values in the science curriculum. The answers to both these questions were, in general, that they do have a common understanding (within limits) and that they do value the inclusion of indigenous understandings and worldviews when teaching science. However, there is a paucity of data on the existence and influence of traditional indigenous Xhosa cultural taboos in terms of teaching culturally sensitive topics such as human reproduction, particularly in rural Xhosa contexts, and the limitations they might impose in terms of the type of language and lexicon adopted by the teachers. As such, we explore the issue of how Xhosa culture may influence the teaching of human reproduction by Xhosa teachers. More so, we explore how homogeneity, that is, sharing common ethnicity with learners, influences the teachers' selection and delivery of human reproduction content such as menstruation, ejaculation, the structure of the testes and fertilisation.

Our concern with taboos is due to a general understanding that there are ingrained cultural beliefs that prevent talking about content viewed as culturally sensitive (Chilisa, 2012; Gee, 2008). Therefore, this paper explores cultural taboos and their possible influence on Xhosa teachers' use of language and lexicon (both in English and isiXhosa) when teaching human reproduction in rural schools situated in communities that hold firmly to their cultural practices and beliefs.

CULTURAL BELIEFS AND LANGUAGE

Central to the discussion is a previous study among Xhosa communities residing in rural Eastern Cape villages (Webb, 2013) which affirms the awareness of teachers, parents and pupils of the importance of integrating traditional knowledge in the school science curriculum. However, there is a paucity of data on the existence and influence of traditional Xhosa cultural taboos in terms of what teachers may say and what words they may use when teaching culturally sensitive topics such as human reproduction.

Culture is a 'social legacy the individual acquires from his group, a way of thinking, feeling, and believing' (Odora Hoppers, 2009, p. 604). Odora Hoppers (2002) advances a view that culture is the collective property of a group and manifests itself in learned behaviours, forming a pattern that shapes values from generation to generation. Foregrounding the issue of culture, Chilisa (2012) raises two types of values that are relevant for the study, namely: built-in, unconscious societal values which lead to preferences over certain things. Secondly, collectivism as a societal value that requires an individual to be part of a tightly knit social framework where people are loyal to the group. Further support for collectivism is proposed by Triandis (2018), who posits that culture is a 'collective phenomenon' (p. 4).

Pertinent to this paper, is the need to explore firstly whether the Xhosa teachers in rural areas are bound by collective, cultural taboos in the teaching of human reproduction. The second point is to determine whether conscious and unconscious societal values have influenced the participants to prefer using certain metaphorical words instead of standard biological terminology (Levinson, 2006; Nieto, 2006). Studies suggest that standard, biological terminology should be used for sexual terminology instead of euphemisms and colloquialisms (Chamany, Allen & Tanner., 2008; Doidge & Lelliot, 2016; Nieto, 2006).

Yore and Treagust (2006) note that there is a 'three-language' problem when teaching and learning science, namely the casual language used at home, the academic language of schooling, and then the peculiarities of the language of the discipline. An additional or 'fourth language' problem in South Africa is that the Language of Teaching and Learning in the majority of schools is English while the majority of learners are not English first language speakers (Webb, 2009). This issue is compounded in the Eastern Cape, where isiXhosa first-language speakers are most often taught in English by isiXhosa first-language teachers (Webb, 2009; 2013). In the rural contexts of the Eastern Cape, English can be considered to be a foreign language for most rural children (Webb, 2017), consequently bringing into even clearer focus the fourth language problem faced by learners and teachers. In the context of this paper, a fifth language problem could be taboo restrictions on language and lexicon, namely '*the things we do not talk about'*. As such, this study explores the issue of cultural taboos and the possible restrictions they may impose when teaching topics that are considered culturally sensitive.

METHODOLOGY

This small-scale exploratory research study, consisting of twenty-nine (29) secondary school Life Sciences (LS) teachers and one (1) LS Subject Education Specialist (SES), took place in the Ngcobo district of the Eastern Cape, South Africa. In the Department of Basic Education, an SES is responsible for managing all subject-specific teachers in an education district. The study comprised 12 male and 18 female respondents, with ages ranging from 25 to 60 years. In the new South African National Curriculum (Department of Basic Education, 2011), human reproduction content knowledge falls under Life Sciences (LS), a subject that used to be called Biology in the old curriculum. Therefore, the term LS has been used throughout the paper in keeping with current trends. Mindful of the aim of the study, data were generated on the participants' current perceptions on teaching culturally sensitive sexual content (Taylor, 2011) framed in an ethos of mutual respect of their cultural heritage, human dignity and restoration of cultural identity (Webb, 2013).

As noted above, fieldwork with all respondents (n=30) was carried out in the Ngcobo District of the Eastern Cape. The setting is one of poorly maintained rural secondary schools (the schools in which the teachers who participated in this study teach) and poorly maintained, rugged and dusty gravel roads serving picturesque traditional villages of scattered rondavels and zinc-roofed rectangular houses from which learners in school uniform walk to school. Traditional herdsmen are often seen on horseback, while women dressed in Xhosa traditional attire are ubiquitous, carrying water buckets on their heads (no piped water is provided to residents in the area).

Qualitative exploratory, semi-structured questionnaires were issued to participants as the first step of a cyclic, flexible, design-based Participatory Action and Learning Action Recursive (PALAR) model (Zuber-Skerrit, 2009). Participants were issued with numbered questionnaires to be able to locate a specific questionnaire in case of errors. The aesthetic appearance of the questionnaire was colourful and simple, based on a study of Eastern Cape township teachers and learners of Xhosa ethnicity by Simayi and Lombard (2019) where it was found that doing so increased participants' attention span. The first section of the questionnaire consisted of simple, closed questions with instructions where participants had to make a mark on the chosen demographical

option. Closed questions were designed to ascertain demographic factors in order to accumulate empirical evidence about cultural issues and taboos and to provide contextual similarity, namely that of being a rural school with comparable ethnicity (Denzin, 2012). The second part of the questionnaire consisted of semi-structured questions, giving participants an opportunity to write how they felt when teaching human reproduction topics such as fertilisation, ejaculation, menstruation and sexual organs.

Inductive thematic data analysis was used to organise the data into patterns and themes, and a coding scheme was developed (Denzin, 2012). The first step of data analysis was used to describe statistics on the demographical area of the questionnaire (Creswell & Plano-Clark, 2007). The aim was to describe the target population, for example, Xhosa ethnicity, rural positioning of the school, LS as a subject taught and gender inclusivity to ensure that we had sampled appropriately. To give meaning and change raw data into meaningful patterns, we started with manual coding using sorting, writing and labelling (Creswell & Plano-Clark, 2007). Coding was used to group similar evidence and labelling to give a wider perspective. In the process, a story emerged as the text was used to generate themes and categories for understanding. The second step of thematic data analysis described the characteristics derived from the data coding in order to make connections between data and the original or emerging research question. The final step was the interpretation where participant responses were organised in the colour-coded categories to indicate emerging themes.

FINDINGS

Thematic analysis of the data generated by the questionnaire revealed that cultural taboos do restrict the teaching of human reproduction by the Xhosa ethnic group teachers who were part of this study. Specifically, findings indicate that there is a fifth language issue that is indicated by Xhosa cultural taboo restrictions on the language used to teach human reproduction. Examples of responses which speak to this claim are presented below. I represents a question while T represents a particular teacher's response.

1 I: Do you think that teaching human reproduction content such as fertilisation, menstruation and ejaculation is part of the normal cultural conversation among young and old members of your culture? Explain your response.
2 T1: No, we don't talk about sex issues in our homes. When I teach these topics '*I double up and make serious faces'* because these learners are naughty.
3 T2: *Asibizi*, meaning 'we do not talk about those things' and '*siyahlonipha'* meaning 'we respect; we are disciplined'. We stay with these community members and are raised to respect our elderly people and cultural laws as forbearers and holders of authority in our culture.
4 T3: No, it's called '*amanyala*' meaning 'vulgar and culturally offensive'. Traditionally we don't talk about such things - '*asibizi'*.

The responses of T1, T2 and T3 illustrate the collective view that talking about sexual matters is taboo in the Xhosa culture. For example, T1's view of 'we don't talk about sex in our homes' reveals a fifth language issue (restriction) where Xhosa cultural taboos are inherent in an individual's personal life and home environment. These taboos result in avoidance of talking about and pronouncing human reproduction terminology. Similar views, based on collective, prohibitive Xhosa beliefs on talking about sex-related issues, were shared

by all the participants. For example, T2 uses the vernacular *asibizi* to illustrate the avoidance of naming human reproduction processes. A*sibizi* is also cited by T3, coupled with an explanation pointing out that tradition prohibits talking about human reproduction terms. Similarly, T3 believes that Xhosa cultural taboos regard talking about sexually related content as vulgar and culturally offensive (*amanyala* in isiXhosa); hence such talk is prohibited.

Compounding the teachers' situation is the matter of cultural identity in the form of *'asibizi'*, and *'siyahlonipha'* (we respect) as community members regard teachers as reservoirs of traditional and moral values where practices that have sustained Xhosa people for many generations have to be preserved. Teachers shared the view that they knew *inwardly* that they should 'avoid language of a sexual nature as it is offensive', confirming the role of culture as an ingrained, cultural belief that has unwritten rules. For example, T2 raises the issue of respect accorded to elderly community members as another cultural restrictive influence on teaching human reproduction. T2 points out that they have been raised to respect cultural laws and elders as holders of cultural authority.

Our findings show that Xhosa teachers share a common worldview where taboos induce feelings of shame, as indicated by T1. The issue of fear was glaring, where the respondent (T1) had to change facial expression. '*I double up*' is a colloquial expression used mainly by young people to explain '*changing the facial expression to a serious appearance'* as a defence mechanism when teaching the section on human reproduction. Furthermore, our findings indicate that Xhosa teachers share feelings of anxiety when teaching sexually related content to learners of similar Xhosa culture.

Anxiety was indicated by T4 where the respondent indicated that talking about sexual matters puts him in a *scary situation* because the problem is that the learners are waiting for the teacher to say those Xhosa terms that they know are prohibited in Xhosa culture. The challenge may be that learners will tell their parents in their traditional, rural environments and teachers may be viewed as disrespectful and far-removed from Xhosa practices.

Our findings reveal the need for cultural identification among Xhosa teachers. For example, T6 raises a compelling and collective authority that avoids talk about human reproduction, expressed as '*we must continue to be torchbearers of our culture and avoid using sex talk'*. Other respondents (T4, T5, T6) confirmed that Xhosa cultural taboos prevent them from talking about sexually related issues as something which is *not* done (T4) in our Xhosa homes when children grow up.

Also, our findings indicate that Xhosa cultural taboos are 'built-in' values and language that conflicts with what they are supposed to teach at school are, therefore, a fifth language issue. For instance, T5 believes that the school puts teachers in a difficult situation where they have to talk about these *things*. Difficulty and uneasiness in talking about human reproduction concepts can be seen from the teacher's avoidance of using standard biological concepts and terms, referring to them as *things.*

5 T4: Conversation about puberty and sexual parts is *not* something done in our Xhosa homes when children grow up. The problem is - learners know there are Xhosa words that are not talked about

in our culture. This puts me in a scary situation as I can't explain these things in my home language.

6 T5: It's our belief and we've been brought up to avoid talking about sexual issues - now at school, we are in a difficult situation as we have to talk about these things.

7 T6: We must continue to be torchbearers of our culture and avoid using sex talk while we have to teach the subject; that is a big language and moral problem to me at my age.

Our findings suggest a situation where Xhosa teachers are strongly influenced by collective, cultural taboos in the teaching of human reproduction in their rural spaces. We base this view on the excerpt, among others, from T2 '*we stay with these community members and are raised to respect our elderly people and cultural laws as forebearers and holders of authority in our culture'*. Further, T6 believes that '*we must continue to be torchbearers of our culture*', indicating an affinity to collectivism.

Living with elderly community members in a rural place and teaching their children, raises an internal conflict where the teacher believes he or she has to gain and maintain the respect of the elders by avoiding culturally offensive human reproduction language. Culturally offensive language is seen in T3's response '*No, it's called amanyala - vulgar'*, raising a point that the teacher does not want to be seen as disrespectful, ill-disciplined or bad by village members. Therefore, it can be claimed that there is a fifth language cultural conflict with the demands of the curriculum that restricts the teaching of human reproduction in rural Eastern Cape schools where the teachers and pupils are homogeneously ethnically Xhosa.

As indicated earlier, this study is preliminary and explores the presence and influence of Xhosa cultural taboos when teaching human reproduction. Our findings raise a question pertaining to the delivery of quality teaching and learning, namely, how do Xhosa teachers teach a subject where they cannot say the standard, human reproductive terms? In line with this question, this research remains an ongoing process which aims at generating further findings and possible solutions during the next data collection phase of the study.

CONCLUSION

In this paper our principal claim, based on the empirical questionnaire data, is that cultural taboos embedded in cultural beliefs of Xhosa-speaking communities restrict the teaching of Life Sciences concepts of a sexual nature in terms of language and lexicon use; namely, what teachers are allowed to say and the words that they are allowed to use. Cultural taboos add an extra dimension to the challenges of the home, school and disciplinary language problems of science teaching as described by Yore and Treagust (2006). Such taboos go beyond the language challenges of learning in a second language as they do not depend on whether the teachers use English or the home language of their pupils. In other words, although the effects of taboos are reflected in language and lexicon, they appear to be independent of any particular language used as they are primarily embedded in the culture. Nevertheless, they still remain a language issue and can be seen as a 'fifth language issue' which needs to be considered when teaching science in schools situated in communities where such taboos exist.

While these findings are preliminary, the authenticity and homogeneity of the responses produced by the

small sample of teachers in this study suggest that further research in this field should provide meaningful insights into issues hindering the teaching and learning of taboo topics. These insights could possibly be used to stimulate the development of teaching and learning strategies that, while respecting cultural beliefs, allow the required content and understandings expected by the curriculum to be delivered.

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SCIENCE AND SCIENTIFIC TEMPER

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According to the Constitution of India (Article 51 A), it is our fundamental duty to inculcate 'scientific temper'. National Curriculum Framework 2005 also looks at the development of scientific temper, as one of the aims of science education. Though scientific temper is not confined to science alone, the possibility of developing scientific temper seems higher in science, as it stands as the most reliable source of knowledge and understanding. We expect science teachers to help children to understand what is science and its influence on human life. So, it becomes important to understand what science teachers think of science. A teacher's identity gets constructed based on her belief, perceptions, experience, values, and judgments. Because a teacher has a moral influence on the students, these need to be examined (Bukor, 2011).

Keywords: *Scientific Temper, Nature of science, Method of science.*

SCIENCE TEACHERS' PERSPECTIVE ON SCIENCE AND SCIENTIFIC TEMPER

Science is a process of understanding the natural world, through the inquiry, in which one applies the methods of science such as – Observation, Induction, and deduction etc. Through inquiry, science explains the phenomenon/entity and provides justification for that for example by suggesting theories. Sarukkai writes scientific theories are unique because they not only describe but also explain and also do the job of unifying the diverse phenomenon (Sarukkai, 2012) "Explaining, categorizing, detecting causes, measuring and predicting are other aims of scientific activity" (Bird, 1998).

Science as knowledge is falsifiable (and verifiable to some extent) and changeable as the process— there is no fixed set of features, which makes something 'science'. According to Popper, a theory is scientific if it is falsifiable (Popper, 1992).

By considering the nature and methods of science, science education has been assigned for an important role of developing scientific temper — according to the national focus paper on teaching of science, one of the aims of science teaching is to develop scientific temper (ST) in students. "*Aim of science education is to cultivate 'scientific temper'- objectivity, critical thinking and freedom from fear and prejudice*." (National Focus Paper on Teaching of Science, 2006).

Scientific temper is an attitude, where one applies the methods of science in the day to day life, to solve the

problems of individual and of society by taking the ethical/moral, social and epistemic values into consideration (Sharma, 2018). To have a scientific temper, one does not necessarily need to go through science education. But science education can help to inculcate scientific temper as the process of science education helps in internalizing the methods and value of science.

In India firstly Pandit Jawahar Lal Nehru introduced the term 'Scientific Temper' in 1946 in his book 'Discovery of India'. He referred to scientific temper as "*a way of life, process of thinking, a method of acting and associating with fellow men"*. Nehru also believed that if India wants to develop strong and vibrant societies like European societies then it had to learn and behave scientifically. He mentioned scientific temper as one of the national goals. By scientific temper, Nehru meant "*fostering the empirical and rational way of thought and life*" (Parekh, 1991). According to article 51(A) of the Indian constitution, it is the fundamental duty of the citizens of India to develop scientific temper and having the spirit of inquiry.

The first statement on scientific temper (1981), given in a conference by Dr Raja Ramanna, Dr. PM Bhargava, and PN Haskar, also explains that it is important to have scientific temper for the survival and future of the nation. According to this statement, scientific temper (ST) should be fostered with care at the individual, institutional, social and political level (Pre-Proceeding from International Conference on Science Communication for Scientific Temper, 2012). In this conference, the need for developing scientific temper was identified and some areas were selected to develop scientific temper, education was one of them. According to the statement, scientific temper is neither an accumulation of knowledge nor rationalism, but rather it is an attitude of mind or the way we approach our problems.

METHOD

The purpose of the study was to understand science teachers, as well as teacher educators' understanding of science and scientific temper. Regarding science, the focus was on nature, methods, and values of science. In education, teachers play an important role — we expect science teachers to help students to understand what is science and its influence on human life. So, it becomes important to understand what science teachers think of science. A teacher's identity gets constructed based on her belief, perceptions, experience, values, and judgments. Because a teacher has a moral influence on the students, these need to be examined (Bukor, 2011). So, this study was an attempt to get an insight of science teachers and teacher educators' understanding of science and scientific temper.

This qualitative study, which spanned for six weeks, was conducted at the Homi Bhabha Centre for Science Education (HBCSE), Tata Institute of Fundamental Research (TIFR), Mumbai. The study was done with eight school science teachers and two teacher educators, from an institute in Mumbai. All the science teachers are actively engaged in science teaching. Out of eight teachers, seven teachers hold a degree of master in science, and one teacher holds a degree of bachelor in science.

In the initial part of the study, teachers were asked to fill a questionnaire. The questionnaire responses were followed by semi-structured interviews. The questionnaire engages with nature and aims of science and

attempts to understand science teachers' standpoint on various current socio-scientific issues. The interviews were more focused on the nature of science, methods, values of science and scientific temper.

The interview questions are given below. Other than these questions, the question 'when do you call something scientific?' or something similar to this was being asked, as almost all the participants (except one teacher) used the word 'scientific' in either interview or questionnaire.

Some of the interview questions were -
1 How is science important?
2. Does science help you to make life better? How?

According to you what are the objectives of science teaching?

Do you think science (as taught in the schools) has the potential to develop values in students? What values? What made you think so?

Do you think science is different from any other domain? How?
According to the constitution, it is our fundamental duty to have a scientific temper. What is scientific temper according to you?

Why there is a need to develop scientific temper? Do scientific temper plays any role in the development of society? How?

PARTICIPANTS' RESPONSES

The responses of the participants were quite different in some aspects and common in others – there were different kinds of understanding. On one end, a teacher, who has a good understanding of nature, methods, scientific temper and believed that science is influencing humans positively. On the other end, participants who had confusion about the impact of science on human lives and looked at science as a school subject, which has some information about the world.

Science teachers' perspectives on different themes

Nature of science: Most of the teachers think that science gives us 'facts' or description that of truth about the natural world. Only a few of the participants (two teachers and teacher educators) understood the falsifiability of science. Also, on a question "when do you call something scientific"(almost all the participants used this word, either in the questionnaire or in the discussion, except one participant). Five out of seven teachers answered "*something is scientific if, it can be proven*", the other two participants answered, "*If something follows a particular sequence and goes step by step*". It wasn't clear here if they were pointing at any regularity here. Most of the teachers look at description and justification as the crucial thing about science.

So, according to most of the science teachers, the nature of science is descriptive, where it tells us facts about the natural world and provides justification for these facts. Only two science teachers in the study mentioned that science also does the job of explaining the phenomenon.

Methods of science: Most of the participants considered observation and/or experiments as the methods employed in science. Only a few of them (two teachers) could identify induction, prediction, and heuristics as some other methods of science. Also, most of the participant thought that there is one particular sequence we follow in science, which is the scientific methodology. Some of the science teachers in the study thought that by doing activities we get to learn the scientific methods because students internalize the process.

Also, participants' understanding of the nature and method of science and scientific temper seems to be correlated. Participants who have shown scientific attitude towards some of the issues included in the questionnaire had a comparatively clearer understanding of the nature and methods involved in Science — they could identify prediction, heuristics, detailed and careful observations (rather than mere observations).

For example a teacher who understood about falsifiability of science. During the discussion on Sabarimala issue participant mentioned – "*we should allow around hundreds of women to go into the temple then only we can conclude something.*" The participant thinks, by experimenting we will get to know about cause and effect.

While another teacher, who believed that science tells us the truth only. On Sabarimala issue the participant mentioned – "*women should be focusing on work, there is no need to go to the temple.*"

Scientific Temper: According to the participants, scientific temper is an attitude/behaviour/ perspective/ ability, which can be developed through science education but science education is not necessary to have scientific temper. Some of the science teachers in the study believed that doing science and history of science helps in inculcating scientific temper. However, they could not explain how doing science helps in inculcating scientific temper.

While explaining scientific temper, most of the participants correlated it (scientific temper) with methods of science. They mentioned:

"*True observation and then analyzing— and rationalizing it over there with that attitude, this attitude is nothing but scientific temper*". (Teacher -1)

According to the participant we do careful observations when we have the scientific temper. (Teacher-2)
"*Lab work helps in developing scientific temper because we do experiments there*". (Teacher-4)

Values of Science: Almost all the participants believe that science education has the potential to develop some values (epistemic or ethical or social). The participants identified some of the epistemic, social and

ethical values of science. In epistemic values, participants mainly looked at truthfulness, curiosity and scientific temper as some of the values. Also, most of the participants thought that Science makes us more sensitive towards the environment and social issues.

One participant had the belief that science is harming the existing value system. The participant mentioned – "*Now a days if you say something to the children, they ask many questions and do not listen and respect elders. Science and technology is harming our culture and values*"

Objectives of science teaching: Science teachers in the study mainly looked at constructing content knowledge as the aim of science teaching. Out of eight, five science teachers in the study mentioned that they taught Science to provide knowledge/ understanding of content to the students. Other two teachers mentioned that they teach science to develop scientific/ analytical thinking among students. While one teacher mentioned that by teaching Science, the teacher tries to develop certain skills in children— such as, the skills of doing activities (doing science).

Science and individuals' belief: Participants seemed to be in dilemma with regard to their belief because of their education in science and belief they held. They tried to prove their belief as scientific; for example a participant mentioned - Science should not influence our life, because it is uprooting us from the culture but on the other hand, the teacher tried to prove religious beliefs and rituals as scientific.

Probably, it was because of the education they have gone through. Probably their science education contributed to the perspective that one needs to have justification to believe in something.

By keeping the practices of science in mind participants tended to prove their cultural and religious belief as scientific. To prove those beliefs as scientific, teachers try to co-relate it with the concepts of Science or scientific knowledge. It seems like dressing up religion as science, as some of the philosophers also regard creationism as 'religion dressed up as science' (Bird, 1998).

For e.g. - To prove astrology as scientific, a participant mentioned - "*may be like gravitational force, the magnitude of the star's effect is very very less that we can't notice that, but definitely stars have an effect on us, same as our neighbours have an effect on us*".

One another participant mentioned; "*Scientific reason behind doing puja of the Peepal tree is that when we do puja we are spending more time under the tree, in that way women will get more oxygen, it is important because earlier women were cooking food on chulhas so, they were in contact of carbon dioxide for a long time*".

According to four participants, whatever our rituals and traditions are, all have a scientific reason behind. It is probably that we are not aware of all those reasons. Another three participants thought that there are some wrong practices in our religion, ritual, and culture, which are ethically not good and they are not logically consistent; these had to be abolished, but not all. So, in a way, there was a range in participants' opinions.

Some of the participants were being little diplomatic— politically correct in answering. For example, most of the teachers mentioned in the questionnaire that menstruation is a biological process, there is nothing impure in this. However, in interview some of them mentioned- *"why women want to go to temple during periods, they should better take rest"* or *"women should be focusing on work, there is no need to go to the temple."*

CONCLUSION

Participants believed that science has the potential to develop some values, such as - scientific temper, which is an attitude/behaviour /ability/realization. But it's failing because we are more oriented towards content knowledge. So, they thought there is a requirement of something more apart from content knowledge.

Also, it was evident that science teachers in the study hold some alternate ideas and misconceptions about science and scientific temper and have not rationalized the aim of science education. This presents a need for emphasizing more on the nature and methods of science — the underlying philosophy of the subject in school science education and teacher professional development programmes along with the content knowledge. Additionally, the aims of science education needs to be explained/rationalized to science teachers.

The science teachers in the study tried to prove their belief as scientific — they tried to make some connections of their belief with the scientific knowledge they hold, even when science education is focused mostly on content knowledge. This indicates that there is some hope that by making adequate efforts (by focusing on the nature and methods of science along with content knowledge) our aim of developing scientific temper can be achieved through science education.

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ANALYSING WATER-RELATED TOPICS IN SCIENCE TEXTBOOKS FROM SUSTAINABILITY AND SOCIAL JUSTICE PERSPECTIVES

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This article explores how the Indian school science curriculum deals with social justice and sustainability with reference to water-related topics. The three pillars of sustainable development as put forth in Rio Earth Summit (1992) were used as the framework to explore sustainability and social justice perspectives in NCERT EVS (grade 3-5) and science (grade 6-10) textbooks. As the terms 'social justice', 'sustainability' and 'sustainable' are not mentioned frequently in the curriculum so the water-related topics were examined carefully to investigate signs of content related to sustainability and social justice using the key developed by Jóhannesson et al (2011). The analysis revealed that sustainability and social justice perspectives are discussed more in textbooks for primary and secondary level as compared to the upper primary level.

INTRODUCTION AND REVIEW OF LITERATURE

'Water is for one and all', this phrase implies equal access to water to everyone irrespective of one's class, caste, race or gender and, also for sustainable use of water to ensure the availability of potable water for future generations. The challenge to make potable water accessible to all is more pressing than ever due to lack of formal water provision, unequal distribution and water pollution.

The unjust exploitation of natural resources for economic development has given rise to many concerns. The relationship between development and environment led to the conceptualization of sustainable development (Adekunle, 2017). According to Langhelle (2000), the term 'sustainable' was first used in a report made by the working group within the World Council of Churches in 1976. He cited the following excerpt of the report from Birch et al. (1979)

> *The twin issues around which the world's future revolves are justice and ecology. 'Justice' points to the necessity of correcting maldistribution of the products of the Earth and of bridging the gap between rich and poor countries. 'Ecology' points to humanity's dependence upon the Earth. Society must be so organised as to sustain the Earth so that a sufficient quality of material and cultural life for humanity may itself be sustained indefinitely. A sustainable society which is unjust can hardly be worth sustaining. A just society that is unsustainable is self- defeating. Humanity now has the responsibility to make a deliberate transition to a just and sustainable global society.* (p.296)

This conceptualization of sustainable society clearly has a social justice mandate which got lost or subsumed within the discourse that conflated 'development' and 'economic growth'. In Brundtland report (1987), sustainable development is defined as the development that meets the needs of the present without compromising the ability of the future generation to meet their own needs (Langhelle, 2000). Such conceptualization of sustainable development does not consider the existing social inequalities. The most widely conceived notion of sustainable development is highly anthropocentric though alternative ecocentric views are also put forth.

Agyeman, Bullard and Evans, (2002) argued that the concept of sustainability is not limited to environmental aspects only, it must consider the aspects of social justice where *questions of social needs and welfare, and economic opportunities are integrally related to environmental limits imposed by supporting ecosystems*. What role does class, race, caste, justice and equity play in sustainability? According to Agyeman (2008), inequity and injustice resulting from racism and classism [and casteism] is bad for the environment as well as for sustainability as broadly conceived. Langhelle (2000) also viewed social justice as an integral part of sustainable development. He opined that development and environmental policies, as well as the strategies and priorities, are greatly influenced by the way the relationship between social justice and sustainability is perceived.

In Rio Earth Summit, 1992, three pillars of sustainable development were put forth, which are: Environmental Protection (Environmental sustainability); Social welfare and cultural integrity (Social sustainability); and Economic development/prosperity (Economic sustainability) (Nightingale, 2019). The main objective of development is to maintain the balance between these three pillars to attain sustainability. According to Nightingale (2019), environmental sustainability is assumed to be the most important and the views vary from highly anthropocentric to ecocentric. Social sustainability mainly focuses on social justice dimension. Social justice supports the idea that everyone deserves equality in economic, political, and social rights, as well as equal access to important human rights (Adams & Bell, 2016). It aims for the total transformation of society to bring social justice by addressing social inequalities. Economic sustainability is argued to be the main pathway to sustainability (Rio Earth Summit, 1992). Many argue that economic growth is necessary for achieving sustainability. According to these people, poverty causes overexploitation of resources and therefore leads to environmental degradation. Whereas another group of people consider global capitalism as fundamentally unsustainable causing inequalities among societies and *overexploitation of ecosystems*. They advocate for alternative economic relations (Nightingale, 2019). Economic sustainability is given the most consideration while making policies on sustainable development.

Education for Sustainable development (ESD)

The central focus of ESD is to prepare students to become responsible citizens by enabling them to participate meaningfully in community-related issues and adopt a sustainable lifestyle by taking the responsibility for both themselves and future generations (de Haan, 2006). According to Wheeler (2000), ESD should aim at developing a deep understanding of complex environmental, economic and social systems and recognition of the importance of interconnectedness between these systems. According to McKeown and Hopkins (2007), most of the ESD models advocate an issue-based and interdisciplinary approach to bring together different

perspectives towards a socially relevant contemporary issue. Science and technology plays an important role in the social and economic development of any society and many issues/concerns regarding sustainability have their links with science and technology either in their genesis or in solutions. Therefore, science education is at the core of the ESD.

Water-related issues like water pollution, the disappearance of water from lakes and rivers, depletion of groundwater etc. are in news since last two-three decades and now the situation has become severe. Now, many areas including major cities around the world, are facing water shortage and water contamination issues. There is a need to take immediate actions to sensitize people, students and common people alike towards such serious water crisis. The present paper aims to explore what water-related topics are covered and how sustainability and social justice perspectives are incorporated in NCERT EVS and science textbooks.

SAMPLE AND METHOD

For this study, NCERT EVS (Environmental Studies) textbooks for grade 3-5 and science textbooks for grade 6-10 were analysed from sustainability and social justice perspectives using the three pillars of sustainable development as put forth in Rio Earth Summit (1992) as the framework. NCERT textbooks are the most widely used textbooks in India. As recommended by NCF-2005, NCERT textbooks for primary level (EVS, grade 3-5) are based on an integrated approach, therefore science and social science are integrated as Environmental Studies. Although NCF-2005 advocates for integrated curricula, the syllabus represents collection curricula where themes are not connected but are isolated. Water-related topics are part of the syllabus at all grades, however, the topics are fragmented.

The descriptive content analysis method was used for textbook analysis. First, the chapters which included water-related topics were selected. Then, these chapters were analysed using the key developed by Johannesson et al. (2010) to study the signs of sustainable development. This key has seven characteristics: values, opinions and emotions about nature and environment; knowledge contributing to the sensible use of nature; welfare and public health; democracy, participation, and action competence; equality and multicultural issues; global awareness; and finally, economic development and future prospect. The selected chapters were read carefully and the content manifesting any of these characteristics was selected. The selected content was then categorised into social, environmental and economical aspects of sustainable development and analysed from the social justice perspective.

ANALYSIS AND DISCUSSION

The textbook analysis discussed in the following section will reveal what water-related topics are covered and, where and how sustainability and social justice perspectives are incorporated in NCERT EVS and science textbooks.

Water-related topics covered in the NCERT EVS (grade 3-5) and Science (6-10) textbooks

Water-related topics are covered in at all levels, primary (grade 3-5), upper primary (grade 6-8) and secondary

level (grade 9-10). There is at least one chapter or one section at each grade level which is devoted to 'water'; however, the content covered in these chapters is repetitive, focusing mainly on water sources, their use, water shortage, water pollution and rainwater harvesting. For example, surface water pollution is discussed through an example of river Ganga in grade 8 (Ch-18) and, also in grade 10 (Ch-16). Table 1.1 represents the water-related topics covered in science textbooks (grade 3-10).

Water related topics	**NCERT textbook (numbers indicate the grade level)**
Fundamental concepts: forms of water, properties, water cycle	3,5,6,7,9
Water availability	7
Sources: Fresh and salt water sources	3,6,7
Uses: domestic; Agricultural and Industrial	3,4,6,9
Water shortage	3,4,6,7
Initiatives to deal with water shortage: rain water harvesting, revival of lakes and ponds, sustainable use of water	3,5,6,10
Water pollution	4,7,8,9,10
Cultural references	3,5

Table 1: Water-related topics covered in the textbooks

The major emphasis in lower grades is on water shortage issues whereas in higher grades emphasis is shifted to water pollution. While discussing the uses of water, domestic and agricultural uses of water are discussed repeatedly in textbooks across the grades whereas industrial use of water is not discussed significantly. Also, in the case of water pollution, as contributing factors, domestic waste is discussed the most, followed by agricultural waste whereas, pollution caused by industrial waste is not discussed much in the textbooks. Moreover, throughout the grades, a major focus is on surface water and pollution of groundwater is discussed briefly only in the science textbook of grade 7. The extent and the severity of the impact of surface water and groundwater pollution on human and environment are not discussed appropriately.

The concept of sustainable development is explicitly introduced in science textbook for grade 10 in chapter-16 (Management of Natural Resources). Definition of sustainable development from the Brundtland Report (1987) is given.

> *The concept of sustainable development encourages forms of growth that meet current basic human needs while preserving the resources for the needs of future generations. (NCERT, 2006, grade-10, p268)*

Though no concrete example is provided in the textbooks to help students to understand the meaning of sustainable development, students have been encouraged to adopt environment-friendly habits and make changes in their lifestyle. Attempts have been made to sensitize students towards sensible use of water through activities like calculating how much water is needed per person per day, how much water is available for our use and by mentioning difficulties faced by people in water-scarce areas.

Sustainability perspective was found to be significantly incorporated in textbooks, however, social justice aspect was marginalized except few instances (discussed in the next section). Unlike sustainable development, the importance of social justice is not discussed explicitly anywhere in the textbooks. The interconnectedness of sustainable development and social justice is not brought forth in the textbooks.

In the upcoming sections, the water-related content covered in the textbooks is analysed from a social, environmental and economic perspective. Social justice perspective is discussed within each foresaid section.

SOCIAL AND CULTURAL ASPECTS RELATED TO WATER

Analysis revealed that the textbooks have mainly incorporated the perspective of rural and poor sub-urban societies of India Of the three levels, primary level textbooks were found to be incorporating social and cultural aspects of water-related topics significantly, like discussions on different practices like reuse of water, using 'tanka method' for rainwater harvesting etc. EVS textbook for grade 5 included discussion on how people in the past used to tackle the issue of water shortage sustainably by constructing stepwells and interconnected lake system to store rainwater for yearlong use and how the change in lifestyle of people and neglect of such sustainable water management systems led to water shortage issues at these places.

The EVS textbooks also included discussion on the water-related customs and cultural practices to depict the significance of water to people's lives, for instance, in EVS grade 5 textbook, there is a section on 'customs related to water' with pictures of a bride worshipping a spring and stone carvings near the place of drinking water (p54). Apart from familiarizing and sensitizing students about water-related issues, textbooks at both primary and upper primary level were also found to include many real-life success stories of reviving water bodies by common people including children, in different areas of country, to cite a few examples, Bhima Sangh's successful efforts of reviving water bodies in grade 4 EVS textbook and Bhujpur story of groundwater recharge through rainwater harvesting (p201) and transformation of Alwar district into a green place (p202) in grade 7 science textbook etc.

Social Justice perspective

Textbooks at the primary level were found to incorporate social justice issues like gender and social (caste-based) discrimination, as compared to middle and secondary level. EVS textbooks have incorporated discussions around gender and social discrimination, for instance, in EVS textbook for grade 3, there is discussion on how water shortage in a village of Rajasthan, 'Bajju', impacts lives of women through a picture showing women walking long distances to fetch water for daily use (p134), and students have been asked one word questions like 'Do your neighbors bring water from the same place ?; Are there certain people who are not allowed to take water from there?; Who fetches and stores water in your house?' with the purpose to sensitize children towards issues like caste and gender discrimination (p 21); in EVS textbook for grade-4, issue of unequal access to water is presented through an example of water park in an area (Bazaar Gaon, Maharashtra) where villagers are facing water shortage issues (p147-148). There textbooks have also mentioned other implications of water shortage and pollution like migration, health issues and extra financial burden on people etc. There are also footnotes in EVS textbooks which appeals to facilitators to discuss such issues with

children to sensitize them towards gender and caste-based discrimination and sensible use of water. Though uneven distribution and differential access to water across the country have been discussed in the textbooks, human-induced causes and consequences of unequal access to safe water in terms of health effects and opportunity cost is not discussed sufficiently.

In grade 7 textbook, there is discussion on water pollution due to poor sanitation and sewage and how students can contribute in maintaining the water sources in healthy state, for example, by approaching municipality or gram panchayat to compliant about open drains and sewers (p220). However, there is no space for discussion around the people (manual scavengers) involved in the cleaning of these drains and sewers and what impact does such work has on their lives.

In grade 10 textbook, social justice issues like displacement of people and inequitable distribution of water, etc. caused by mega projects like construction of dams, are incorporated significantly; however, instead of enabling students to think critically about various aspects of these issues and explore connections between these aspects, textbook describes relatively few dimensions of such issues.

Environmental aspects related to water

The main approach in EVS textbooks is anthropocentric, the facts related to water scarcity and water pollution are discussed concerning its impact on human health, whereas, the impact on plants, different animals, and aquatic life, is only briefly mentioned at different levels., The concern for the environment seems to be arising from concern for human welfare, for instance, any attempt that has been discussed in the textbooks to deal with the water shortage or water pollution is made when human health and everyday life is adversely affected; none of the story or incidence is mentioned in the textbooks where any effort is made to save the environment for the sake of environment and well-being of other species. However, the importance of water for different species and its relation to biodiversity is discussed at primary as well as secondary level.

Whereas at the primary level, the focus is more on the water shortage, as we move from primary to secondary level, the focus shifts to water pollution. While discussing water pollution, the textbooks were found to emphasize more on the surface water pollution as compared to groundwater pollution Although textbooks have included brief discussions about the impact of pollution on aquatic life at all levels, the long-term consequences of water depletion and contaminations on the environment are not discussed. The interrelationship between humans and the environment also does not seem to be adequately addressed in the textbooks. The way water shortage is projected in the textbooks, it is attributed more to natural causes and only human-induced cause discussed is an increase in population which has exaggerated the situation; there is not much discussion around water mismanagement issues at local as well as at the national level except in the textbook for grade 10.

Social Justice perspective

Environmental sustainability is an important aspect of sustainable development. Throughout the grades, especially at primary level, textbooks have emphasized sensitizing students towards sensible and just use of

water resources. However, textbooks does not provide much opportunity for students to critically think how does unjust exploitation of water resources by a particular section of the society (for example water-intensive industries like mining industry) affect the majority of people, other species and ecosystems in various ways and create sustainability issues. The issue of water management is essentially an issue of environmental justice (Vanderwarker, 2012) and everyone including the non-human species have right to environmental resources like water. This sentiment is found to be missing from the textbooks.

Economical aspects related to water

Economic development is at the heart of sustainable development. According to Adekunle (2017), a society which is economically more developed is more sustainable. The economical aspect of water is briefly discussed in EVS textbooks. In grade 5 EVS textbook, students are asked to examine the water bill printed in the textbook and find out how much do they pay for water. A few instances, these textbooks also mention that some of the people have to buy drinking water from the market as there is no provision for safe water supply. As the focus at the primary level is mostly on the use of water for domestic purposes, the economical aspect of water concerning agricultural and industrial use is not discussed. As we move to the secondary level, there is a discussion related to cost involved in mega projects like the revival of river Ganga.

You must have heard about the Ganga Action Plan. This multi-crore project came about in 1985 because the quality of the water in the Ganga was very poor (NCERT, 2006, grade-10, p266)

The economic value of water in producing hydroelectric power is also discussed in science textbooks for grade 9 and 10. These instances help make students realize that the water that is supplied to their houses and communities is not free as contrary to popular belief, but it is paid, as there is processing cost involved. However, it is not mentioned in the textbooks that this cost differs from domestic to agricultural and industrial use. There is also no discussion around 'subsidy' provision, what it is, and how it varies for water consumption for different purposes.

Social Justice Perspective

The textbooks of secondary level have incorporated social justice issues that are related to economical aspect of sustainable development, for example, while discussing the mega projects, textbooks at the secondary level address the issues like inequitable distribution of water from the dam, woes of people who are displaced from the site etc. The textbooks for primary and upper primary level were also found to address social justice-related issues like the struggle of people from marginalized section to arrange water for daily use and helplessness in using dirty water for various purposes including drinking, whereas people from a privileged section of society have easy access to water and water purification systems.

CONCLUSION

The analysis revealed that sustainability and social justice perspectives are incorporated significantly in EVS textbooks for primary level and to some extent in science textbooks for secondary level. Whereas science textbooks for upper primary level seem to adopt factual approach and marginalize the sustainability and social

justice perspectives. Additionally, at all levels, the contentious issues that arise because of the complex interaction between human and environment are not adequately addressed. The discourse on misuse and mismanagement of water resources for industrial as well as agricultural purposes is side-lined in the textbooks. For example, cultivation of water-intensive crops in areas with low water table, constructing industries which require a large quantity of water in areas facing water shortage issues, violation of rules and regulations related to waste discharge are not adequately covered in the textbooks.

There are very few instances where students are provided space to think critically about issues related to sustainability and social justice; they are asked closed questions with limited scope for critical and interdisciplinary thinking. There is a need to create space for students within the textbooks to understand and appreciate the complexity of human-environment interaction and reflect on their experiences as a member of the society from a sustainability and social justice perspectives.

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BUILDING A "TECHNICAL CULTURE": EXPERIENCES OF ENGINEERING STUDENTS IN A TECHNICAL INSTITUTE

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This paper seeks to discuss how engineering students' aspirations and professional identities are shaped by the broader neoliberal and patriarchal socio-political structures that they are part of Employing in-depth interviews of six engineering undergraduate students and discussion threads in social media, the paper discusses students' attempts at building technical identities in an educational system that privileges self-motivated learning. Students allude to the deteriorating "Technical culture" in the campus as a hindrance to the development of their technical capabilities. While the article documents how they define the notion of "technical culture", it is striking that the technical culture is especially alienating to women. When it comes to learning, students view the university as a hindrance to and not a facilitator of learning and devise their own strategies to learn-these are documented and interpreted in the light of literature that discusses the impact of neoliberalism on education.

ENGINEERING EDUCATION IN INDIA: STATE OF THE ART

The Nehruvian imagination of postcolonial India positions technoscience as a central actor in the path to modernisation and development (Nandy, 1988). Post-independence, the state invested heavily in science and technology based development projects. Science and engineering thus came to acquire respectability as professions, but were not necessarily seen as lucrative professions, in the manner in which they are viewed today. It was in the 1990s, following liberalisation, that many of the regulations that controlled Indian businesses and foreign enterprises were dissolved and the private sector began to tighten its clutches on the Indian economy.

Engineering as a coveted profession of the middle classes needs to be understood in this context (Khandekar, 2013). The middle classes in India, according to Khandekar (2013), came to pin their hopes on neoliberal-reforms' professions because of a unique set of historical reasons that pitted them against the state. This, along with the unique status that technoscience has always occupied in the vision for development, vests within science and engineering the 'the promise of modernity'.

Modern engineering education of an institutionalised nature in India can be traced back to the colonial era of the 18th century. Since then, the number of engineering education institutions have grown gradually till the latter half of the 20th century. However, it is the 1990s that witnessed a tremendous growth in engineering colleges (Subramanian, 2015). This period ushered in an increased investment in professional education by

the private sector (Srivastava, 2007). Kapur and Mehta (2004) note: "the private sector, which accounted for just 15 percent of the (engineering) seats in 1960, now accounts for 86.4 percent of seats (and 84 percent of all engineering colleges)" (p.6).

However, the quality of these institutions remains suspect. A very small proportion of engineering graduates are considered employable by prospective employers and only a handful of the engineering institutes in the country are considered to be of good quality (Varshney, 2006). The National Employability Report (Aspiring minds, 2016), for instance, which presents a study of the employability of fresh Indian engineering graduates in relation to IT roles, engineering roles and non-technical roles reveal worryingly low levels of employability. Alongside this, the job market is shrinking (Siddiqui & Sharma, 2017). This is perhaps a major reason, along with other social hierarchies prevalent in elite institutions that severe depression among professional college students is reported (Ghosh, 2018). Of late, there have been several media reports of student suicides in top engineering institutes. All of this points to a crisis within engineering education as well as the engineering sector, despite efforts on the part of the government to launch campaigns such as Make in India and Start-up India[1].

THE POLITICAL ECONOMY OF ENGINEERING EDUCATION

Engineering practices and institutions need to be understood in relation to the broader political economy, which, in the present context is overdetermined by neoliberal structural policies. Neoliberalism is a political ideology that emphasises greater freedom of the market, withdrawal of the state from the public sector and subsequently its welfare functions (Carter, 2008). Thus, competitiveness and individualism become acceptable human conduct, which, in the educational context, translates to the learner being expected to "take responsibility for their learning throughout their educational career while showing an adaptable approach to job seeking and reskilling in an employment market characterised by uncertainty and career instability" (Patrick, 2013, p.3). Knowledge comes to be viewed in a utilitarian sense and learning gets equated with the acquisition of 'skills' which can be measured through standardised assessment measures.

It is within this overall scenario that the reported study is being conducted. It seeks to examine the ways in which students reflect the anxieties that are an outcome of the socio-political context presented above and the ways by which they anticipate and negotiate the uncertainty of an educational system that is built on the aforementioned principles.

METHODOLOGY

The study is being conducted in a private engineering institute which, as per the National Institutional Ranking framework (MHRD, 2018), falls within the top 20 engineering colleges in the country. Students are admitted to the institute based on their performance in a national eligibility test. The students hail from fairly

[1] These were launched to boost the manufacturing sector and entrepreneurship respectively.

privileged socioeconomic backgrounds[2] and the men students (82%) outnumber the women students (18%). The model of education within the institute follows the principle of self-motivated learning wherein students have the option to not attend classes and learn on their own. The primary inspiration for the study came from a meeting that the author of this article and a co-researcher attended in March, 2019 wherein students' academic and non-academic issues were discussed. Many students spoke eloquently about the academic culture within the campus. Among others, they talked about inadequacies in the "technical culture" extant in the campus as well as the necessity to hone their "skill sets" to increase their employability. They lamented about the lack of drive and the rising mental health crisis among the students.

In the aforementioned context, our research objective is to understand the ways in which students negotiate their professional educational experience in a system where maximum "freedom" and "choice" is afforded to students to learn and innovate. The time spent in the institution is also a period of time wherein they "come of age" and become solely responsible for their future professional trajectories, which places immense pressure on them. The study can be methodologically placed within the interpretive research tradition and involves data collected through in-depth interviews (of about an hour each) of six engineering undergraduate students[3], as well as analysis of online blogs and discussion threads on social media. The latter were shared by the participants themselves to shed further light on specific concepts that were discussed in the interviews.

PARTICIPANTS

The six students whose interviews are presented here are Akash, Suraj, Ankit, Asha, Seema and Shreya (refer to Table 1 for their profiles). Four of these students were present in the initial meeting that discussed technical culture in the campus and were articulate about their views. The six cases represent i) different areas of specialisation ii) differences in 'techie' identities and iii) different genders. Among the men students, Ankit seems very much a techie, being inclined towards research and development within his domain, while Akash and Suraj have chosen to steer away from engineering into management and finance. Among the latter two, Suraj appears to move seamlessly between techie and management identities, which is evident in his discussion about the various roles he has taken vis-à-vis various technical projects on campus. Among the women students, Asha has chosen to move away from engineering to social sciences, having done excellently in her humanities and social sciences electives. Shreya, at the time the interview was conducted was in a state of confusion regarding what she finds interesting in her engineering branch and was still figuring out what she wanted to do. She had just completed an internship with a start-up in Bangalore and had found the experience useful. Seema has already completed her degree and is working with a non-profit organisation in Karnataka. Her job profile in the organisation is non-technical in nature. She was invited to participate in the study after the researchers came across a Facebook post of hers (from her student days at the institute) regarding the lack of technical culture among girls on the campus.

[2] According to the data on socioeconomic profiles shared by 71% of the students, the parental annual income of 34% of the enrolled students exceed 10 lakh Rupees per annum. 13% earn 6-10 lakhs, 11% between 3-6 lakhs and 7% between 0-3 lakhs. 87% of the enrolled students hail from the general caste category.

[3] The study is currently in its preliminary stages and we adopted a snow ball sampling strategy. We intend to interview more participants who would reflect diversity in terms of gender, caste and class. While this article was being written, only a few participants were interviewed

Participant (pseudonyms)	**Age**	**Specialisation**	**Parental income per annum**	**Caste background**
Akash	20	BE Manufacturing Engineering	10 lakhs	General Category
Suraj	20	BE Electronics and Electrical Engineering	10 lakhs	General Category
Ankit	23	Integrated MSc/BE degree in Physics and Mechanical Engineering (5 year course)	10 lakhs	General Category
Shreya	19	Electronics and Communication	10 Lakhs	General Category
Asha	20	Electronics and Communication	10 lakhs	OBC
Seema	24	Electronics and Instrumentation	10 lakhs	General Category

Table 1: Participants' profile

RESULTS

Students reveal tendencies/aspirations that are circumscribed by the neoliberal as well as patriarchal socio-political context within which their education and profession is embedded. This is evident in their motivations for choosing engineering, their concerns about 'skill sets' that are required to be employable, their disinterest in academic learning, and in their articulations of how they wish to shape their careers in future. However, at the same time, they are agentive and wish to bring about changes to their predicament, which they characterise as alienating. In the following section, we discuss these aspects.

a. Motivations for choosing engineering

Among the six participants, Akash chose engineering because it is a "family thing": there is no engineer in his family. Seema, Shreya, Asha and Suraj also mentioned aptitude in mathematics and sciences as a reason. Suraj mentioned engineering being a "safe option" as a reason for his choice, since opting for the arts or journalism can make it difficult to get placed. All participants except Ankit mentioned that they did not actively chose engineering, and that it was a practical decision, in part guided by their parents. Unlike others, engineering was Ankit's career choice since the 9th standard. His father owned a manufacturing company and wanted him to study mechanical engineering in order to expand the family business. However, in his discussion of why he chose mechanical over computer science too, we see the notion of security (with regard to job security in the event of an economic meltdown) invoked. In sum, all six participants' discourses reflect the typical middle-class Indian mind-set that views engineering as a "safe" and respectable profession for the academically bright.

b. Technical culture

As mentioned, a recurring term that surfaced in the meeting was the notion of the "technical culture". Most students mentioned the necessity to build a technical culture and the lack thereof in the campus. They shared

concerns about how, for most students, life was only about partying and college fests. Ankit, in his interview mentioned that this concern goes back to the year 2016 and shared a Facebook discussion on the matter from a students' Facebook group[4]. The post captures the angst regarding the perceived absence of a technical orientation among students:

[…]

> If tech has been woven in your past, present and future #WeNeedToTalk
> If you have ever been enthusiastic about some tech project but never followed through #WeNeedToTalk
> If you think that our technical culture is not good enough #WeNeedToTalk
> If you want to be part of the solution rather than the problem #WeNeedToTalk

(Dated: 27 March, 2016)

In the interviews, the participants were probed regarding how they understood the term. A technical culture for Akash is a vibrant campus where technical projects are executed. For Suraj, the technical culture of a campus indicates how well a campus knows and is good with its technology. He went on to elaborate that most people on campus were only interested in placements and were not interested in "giving back" to the campus. He discussed the successes and travails of a project that he was involved in which aimed to make the entire campus "smart", through the development of a web-based app. These included the development of services such as a cashless system for money transactions on campus, a bus tracker that would help students on the campus access the bus conveniently and other platforms that would help make life smooth on campus. However, he lamented that the freshers on campus were reluctant to learn web development and coding from the seniors, the former only being concerned about placements.

Ankit too believed that students in the campus were disinterested in immersing themselves in projects, and that they execute projects merely to put them on their resume. For Ankit, apart from hands-on projects that would involve making something in the campus, having fun needs to be an integral part of a vibrant technical culture: "So problem solving and just doing *something for the fun* of it is part of technical culture for me…not just making robots and all that (emphasis added)."

When it comes to the women students and their perceptions of technical culture, Seema's Facebook post is self-explanatory:

> I had this thought running through my head about the Technical culture of the campus, specifically, the plight of the Girls' side of the scenario. It is abundantly clear that the percentage of Girls involving themselves in the Technical Activities is very low compared to Boys. I have been wanting to start working in the fields like Robotics and Web-Dev but the problem is that there is a lack of a specific type of motivation. There is no denying that watching someone work is enough motivation to carry-on. But girls don't have an active environment of this sort where they can go to each other, inspire, get inspiration and learn. Yes, we can do so with the Boys but it is not always comfortable for everyone to go to a completely strange guy and try to learn from him. There are no gender issues but there is no denying that the comfort level varies. I know a few girls who want to do the same but there is no such community and so, there has been no real advancement. So, hereby, I want to propose that the

4 The posts were sourced from a student only Facebook group. Permissions were obtained from the moderators to use the posts pertaining to technical culture without disclosing the identity of those posting.

> girls who want to participate in the Tech-activities join hands by forming an informal group where we come together and work for Projects. Interested girls please comment and based on the response we can proceed further. Please tag the girls you know who would want to join this cause and also, put-in your thoughts about the way we should go with the whole process. (Dated: 27 March, 2016)

When invited to provide more context on the post, Seema shared that a technical culture on campus was absent among the girls since they do not team up and work together. She lamented about the lack of inclination among girls (unlike the boys) to get together and make things. She also mentioned how a lot of informal technical projects were executed by the boys in their hostels which did not happen in the girls' hostels. Furthermore, she mentioned instances wherein she and other girls faced sexism when working with boys. Asha believed that even when the boys are not sexist, they do not perceive women as "one of their kind" to actually work with them. She believed that girls were also more "academic" and individualistic in their approaches to learning. Shreya believed that the sheer fact that the boys out-numbered the girls makes it difficult for the girls, and the existing socialisation patterns in society forbade the opposite sexes from mingling with one another, making it difficult to learn from each other.

c. Skill sets and knowledge

Another phrase that the students used in the faculty-student meeting was the lack of "skill sets" among the students and the need to develop these. In the interviews, we specifically asked participants what they understood by the term. Akash believed that a, "Skill set defines how employable a person is, how flexible or versatile as a person is." Ankit and Suraj did not define "skill set" clearly…but acknowledged that these vary from domain to domain. Both Akash and Suraj believed that learning coding and basic programming are important skills that make one versatile and employable in the job market. Shreya, Asha and Seema were not specifically probed on what they understood by skill sets as they were interviewed later and by then we had realised that students seemed to hold convergent views on what they understood by the term.

d. How to learn

A question that was asked of the participants in the interview was how they go about acquiring the "skill sets" that they deemed missing among students in the campus. All six students believed that skill sets need to be acquired by immersing oneself in a hands-on project that addresses a real-life situation. Akash, for instance, talked about how he learned management and people skills simply through heading the language activities club on campus. Suraj believed that skills can be picked up by immersing oneself in projects that "give back to the community". On probing further, we came to understand that for him the "community" was the campus. He also talked at length about mentoring and learning in the context of discussing the smart campus project. His learning from the entire experience was that the freshers do not learn unless there is a financial incentive. Ankit also echoed the idea that giving back to the community is an important context for acquiring skills. For him, knowing what skill sets to acquire is possible by approaching the seniors. He also believed that learning happens if there are penalties built into the learning process. It is interesting that both Ankit and Suraj held behaviourist models of learning. When probed further about how to acquire skill-sets, Suraj talked about online certified courses, asking seniors, and only finally, the faculty and coursework.

A similar disengagement with academics and coursework was true for both Ankit and Akash as well. Ankit

said that he attended classes only if he is "not occupied with something else". Yet, he believed that keeping "in touch" with professors is important, particularly when executing projects. Akash mentioned that his attendance of the courses offered by his branch (manufacturing) were low because they were repetitive and redundant and he had lost interest in them over time. Shreya, Asha and Seema also revealed a similar perception of disinterest in academic courses. Both Shreya and Seema also talked about learning things online.

All the men participants unequivocally acknowledged tremendous support from their seniors, – or *bhaiyyas* as they reverentially referred to them – in navigating their student life on campus. Akash talked at length about how supportive his seniors have been in terms of hand-holding him through the initial few semesters at college, be it advice about how to manage his CGPA or how to prepare himself for placements. Suraj mentioned the vital role that his seniors played in initiating smart-campus and how they inducted some of his friends, getting them to develop the app and the webpage. It is striking that an analogous woman senior was completely missing in the women students' narratives.

e. What does being a "good engineer" constitute?

The participants were all asked what comes to their minds when they hear the word "a good engineer". For Akash and Seema, a good engineer has good knowledge and the skill to apply it and should be able to innovate things in a way that life gets better for people For Akash, consistency and the willingness to work hard marked a good engineer while for Shreya, it is someone who "gets the job done" creatively. For Suraj, a good engineer is someone who gives back to society, while making profit ought to be a secondary thing. Ankit was unable to define a good engineer, but seemed to think his uncle was one. He believed that an engineer has to be knowledgeable in many areas and capable of systems thinking. Asha too believed that a sound knowledge of science is necessary to be a good engineer. It is interesting that both Seema and Shreya used the word "he" when referring to their conceptualisations of a good engineer.

DISCUSSION

As discussed, the nature of the privatised engineering education that students receive is by and large circumscribed by neoliberal economic processes. This is evident in the principle of self-motivated learning that the institute advocates, wherein complete autonomy is offered to the learner to drive their learning.

Building a technical culture, for the students, is a response to the increasing levels of alienation that they are witnessing on campus which is a direct result of the individualised, self-directed and competitive learning environment they are part of. For the men students, the idea of "giving back" to society or the campus through technical projects figured prominently in their articulations. They believed that engaging in these projects makes one feel rooted, connected with other individuals and their profession. However, it is important also to critically interrogate the idea of "giving back", does this concept encompass notions of social and environmental justice? Our preliminary exploration suggests otherwise. Furthermore, our preliminary investigation reveals that core of the "technical culture" is gendered and patriarchal – in the fact that it is exclusive of women and probably other minorities.

When talking about how neoliberalism has reconfigured teaching-learning, Patrick (2013) writes, "Within the new language of education, the teacher is there to meet the needs of the learner, but these needs are narrowly defined as "learning" needs within a model that reduces learning to a series of teaching inputs designed to meet pre-specified outcomes" (p.4). This view of learning is especially evident in all the students' articulations when they seemed to suggest that course work and the role of the "profs" is only required on an "as-needed" basis. This points to a deeper and graver question of whether under the new scheme of things, a teacher is needed at all.

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FROM *CHARANAMRIT* TO *GANGAJAL* VIA BRINDAWAN-MATHURA-KASHI: CULTURAL POLITICS OF WORD-PROBLEMS IN SARASWATI SHISHU MANDIR MATHEMATICS TEXTBOOKS

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Textbooks are the prime source of knowledge in Indian schools. They occupy sacrosanct status particularly due to memory-based examinations. They are used not only as artefacts of learning but also as carriers of values, beliefs and ideas, particularly of dominant classes. Compared to textbooks of History or Language, those of Mathematics or Physical Sciences are perceived as 'objective' and therefore 'harmless' in the context of social inequalities. In this paper, I attempt to analyse word-problems from Mathematics textbooks of Saraswati Shishu Mandir (SSM) to unpack the structures and layers of gender, caste and class domination. I show how SSM textbooks are overtly prejudiced and argue that contexts presented in word-problems should be locally relevant but without bartering away progressive social outlook.

TEXTBOOK-CENTRIC SYSTEM OF SCHOOLING

The fact that educational discourse in school education in India revolves around paper-textbooks (textbooks hereafter) is well acknowledged by all actors in education – students, teachers, parents, community at large and academics. Completing the syllabus usually means 'finishing' the textbook from cover to cover, and success or intelligence means memorising textbook in verbatim. Textbook-examination nexus has survived all policy recommendations against it. Krishna Kumar (2004, 36) writes:

> The examination-textbook linkage became stronger as the system of education expanded and as the stagnation of work opportunities exacerbated the competitive character of the system. The linkage defeated all attempts to reform the curriculum and the methods of teaching.

The problem is that textbooks do not offer pieces of information but what Michael Apple famously called as 'valid' knowledge that is not neutral. He reminds us that —

> The curriculum is never simply a neutral assemblage of knowledge […] It is always part of a selective tradition, someone's selection, some group's vision of legitimate knowledge. It is produced out of the cultural, political, and economic conflicts, tensions, and compromises that organize and disorganize a-people. (Apple, 1993, 222)

Students and teachers seem to 'willingly' surrender their autonomy to textbooks at the cost of pedagogical choices and methodological innovativeness. M. K. Gandhi too cautions us when he writes that:

> If textbooks are treated as a vehicle for education, the living word of the teacher has very little value. A teacher … becomes a slave of textbooks and has no opportunity or occasion to be original. It

> therefore seems that the less textbooks there are the better it is for the teacher and his pupils. (Gandhi, 1939)

TEXTBOOKS AND HIDDEN CURRICULUM

An apparently 'progressive' curriculum or syllabus can lead to choice of a text loaded with what Phillip Jackson famously conceptualised as the 'hidden curriculum'. By hidden curriculum one understands unwritten transaction and reproduction of beliefs, values, norms, ways of behaviour, or simply 'culture' through formal educational content and informal and other social interactions in a formal setting like school. In a textbook, hidden curriculum can be employed through all of its building blocks including words, images, illustrations, etc. leading to cultural supremacy and stronger socio-cultural power to some section of society, many a times the dominant class. For instance, in the 1920s, in an attempt to raise concerns of the marginalised about politics of the upper castes (formerly touchable castes) in schooling, C. S. Kate, a reader from Solapur, writes in a letter to Marathi fortnightly *Bahishkrut Bharat*, founded and edited by B. R. Ambedkar.

> How bitter are the tongue, gaze and thoughts of the touchables!! Grade 3 Balbodh Textbook Lesson 46 – Occupations in Village. This lesson employs reviled language mentioning caste of the persons like Kusha *dhor* and Parasha *chambhar*. In school-textbooks too the bitterness of their (touchables') tongue, gaze and thoughts is prominently visible. (Kate quoted in Darak, 2013. Translation by Ms. Madhuri M. Dixit)

As evident here, hidden curriculum appears to have been used for either ill representation or misrepresentation or underrepresentation of the marginalised communities at the cost of their self-respect: a fact that is clearly acknowledged by policy documents in India that cultural politics of school-processes leads to 'Brahmanisation as key defining feature of curriculum' (NCERT, 2005 A, 24) and of schooling.

The large body of scholarship on textbook analysis suggests that usually subjects like language and history are prime sites of employing cultural politics through textbooks. Histories of textbook related controversies from across the world also converge with this view. On the other hand, it is assumed that subjects like Physical Sciences and Mathematics, due to their epistemologically 'objective' nature, leave little scope to any socio-cultural variation.

The invariance of answer in a mathematical problem or its independence with respect to the algorithm may create a 'feeling' that mathematics can be independent of context too; but word-problems may be the game-changer. Although word-problems are considered as a pedagogical tool for creating connect of 'abstract' numbers with the 'real' world, which may imply their agency in creating meaning, large body of research on word-problems focuses on utility of word-problems in helping students arrive at desirable answers, on connection between 'nonsensical' answers and wording of problems, or on link between difference in structure of word-problem and variation in students' performance, etc. But cultural politics employed through Mathematics textbooks and patterns of hidden curriculum embedded in word-problems remain underexplored.

Word-problems as a social text

Word-problems attempt to present situations closer to lived realities so that numbers and operations presented in a mathematical text can be contextualised. In doing so, they may succumb to the hegemonic tendency of presenting a particular point of view that is usually familiar to the dominant classes. Richard Barwell explains why treating word problems as texts leads to difficulties in understanding 'unrealistic' responses of students or why their responses may be related to their socio-economic backgrounds, and he argues that "word problems need to be understood as social texts. Early research on students' performance on word problems generally treated them as mathematical texts or, at best, linguistic texts." (Barwell, 2018, 117). If we examine word-problems as social texts, they can be analysed for different aspects of societal relations including ideology, patterns of marginalisation and subordination as well as ways of exhibiting social power. With this outlook in place, Mathematics textbooks may also be treated as a cultural artefact instead of merely a pedagogical tool.

Research in mathematics education focussing on word-problems alerts us to this nature of word-problems. Words, pronouns and phrases used in word-problems, artefacts and goods shown to create real-life situations may create a different meaning in the mind of a learner depending on her socio-cultural background and is a function of 'cultural capital' in Pierre Bourdieu's terms. Designer of a word-problem may come from a different experience of life than those of learners leading to some intrinsic prejudices coded in the words of a word-problem and also in imagining a desired, correct answer. A context which is apparently neutral or value-free may also turn out to be a prejudiced one due to engagement of learners with the situation described in the word-problems. A famous example discussed in scholarship in the field is – It costs $1.50 each way to ride the bus between home and work. A weekly pass is $16. Which is a better deal, paying the daily fare or buying the weekly pass? Tate (1994) argued that the problem designer implicitly assumed that people work for 5 days a week and that one person has only one job ignoring possibility of people working on weekends too and having more than one jobs. This lived reality was imposed on the "neutral" situation by the African American students and led them to choose the 'wrong' answer as 'weekly pass'. The solution was economically prudent and mathematically logical for these students. Such integration of real life situations can be argued to be superficial or be seen as an act of tokenism because the more important question – *whose real life experiences* – is brushed under the carpet. While discussing the idea of 'humanising students' Mathematics curriculum' in the context of unban students, Ukpokodu (2016, 134) cautions us about 'integrating superficial content' in word problems that 'trivializes and stereotypes urban students' lives and their communities.' With appropriate examples of word-problems she discusses how some of the teachers may consider some word problems as intending to be 'culturally responsive' but may end up stereotyping the community as drug addicts or dealers.

Schools across cultures consider textbooks as tools of establishing structural superiority of one class over the other and therefore may show clear tendency of choosing texts that are 'suitable' to their ideology. In her brief but engaging story of Chinese schools in Calcutta, Zhang Xing (2010, 53) describes how in the 1950s and 1960 schools aligned to pro-Guomindang faction (for example Meiguang School in Calcutta) considered textbooks provided by People's Republic of China not appropriate "due to very different ideology" and it explains "how ideological differences in regard to textbooks became a political issue at the Peimei School."

Even though ideological moorings are common to social enterprises, Mathematics textbooks cannot be left outside socio-cultural analysis while unpacking the ideological framing. Research about mathematics textbooks from different cultures reiterates this fact. For example, Anjum Halai (2007, 114) describes mathematics textbooks in Pakistan as carriers of tasks describing –

> [S]ituations which would be culturally regarded as the domain of males. For example, in an exercise of ten word problems, there would be eight word problems favouring boys through reference to their favoured profession and through mentioning male names. This was found in most textbooks whether published by local private publishers or those publishing for the textbook boards.

Thus descriptions in word-problems in mathematics textbooks should also be seen as "'valuative selections' from a much larger universe of possible knowledge and collection principles" and they must be probematised "so that the social and economic ideologies and the institutionally patterned meanings that stand behind them can be scrutinized." (Apple & King, 1983, 84).

WORD-PROBLEMS – EXAMPLES FROM SSM TEXTBOOKS

Following sections discuss the ways in which word-problems can be employed to create a cultural discourse in India. By exploring subtle as well as overt biases I argue that word-problems in Mathematics textbooks can also be used as tools for dishing out certain type of world-view as a valid or official view.

My examples are from elementary grades from textbooks published by one private publication: Sawaswati Shishu Mandir (SSM). They are used by schools established by Vidya Bharati, an outfit of Rashtriy Swayamsevk Sangh (RSS), a right-wing organisation believing in supremacy of Hindu (read Brahman) culture and working towards universalisation of the same. Ideologically the SSMs attempt to build Hindutva (read Bramanism) as a practice among the rural masses. Over the past 70 years since early 1950s, about 25,000 SSMs and similar schools are opened and run by the Vidya Bharati in an attempt to capture the vacuum created by failure of the state to provide schools for children, particularly marginalised children in rural India. Some studies have shown that the discourse of SSMs through their textbooks as well as their daily conduct is highly prejudiced against feminine genders (Chauhan, 2011, 2012) and teaches hatred (Sundar, 2004). But the textbooks chosen for analysis by these scholars are language and history textbooks. With examples of some word problems from grades III, IV and V textbooks, my attempt would be to raise issues arising in 'inclusion of local contexts' and 'lived experience of learners', since National Curriculum Framework 2005 suggests incorporation of "local knowledge and traditional skills, and a stimulating school environment that responds to the child's home and community environment" (NCF, NCERT, 2005 B, ix).

As stated in the preface, the publishers of the textbooks published in 2008 by Saraswati Shishu Mandir Prakashan, Mathura, believe that "Mathematics is the basis of transactions in our life, art, knowledge and science. The key to proliferation of knowledge in science, computer or nuclear weapons lies with Mathematics. But due to lack of interesting style (of presenting and teaching) children consider learning important subject like Mathematics as most complex and difficult." These textbooks of grade 2 to 5, as the preface states, are developed to make mathematics more interesting by "a group of SSM teachers after adequate

engagement with and deliberation on (the topic).” My analysis treats word-problems as social texts that play a role beyond merely presenting a mathematical problem statement to learners.

HINDU GODS, HINDU DEVOTEES

In an attempt to teach concepts of Operations with Metric Units, textbook of grade IV gives the following problems.

1. Height of temple of *Radhaji* (companion or confidant of Lord Krishna) is 143 m. 50 cm. If height of one step is 35 cm, how many steps one needs to climb to go to the temple? (page 88)
2. Virndavan Rangji temple has a pillar made up of 250 kg. 680 gm gold. Dwarikadhish temple of Mathura has golden cradle weighing 200 kg 800 gm and tower of Kashi Vishwanath temple is coated with 251 kg 350 gm of gold. What is the total amount of gold in the three temples? (page 87)
3. Indra’s vehicle is *airawat* (elephant) and Ganesha’s vehicle is mouse. The weight of mouse is about 750 gm and that of the elephant is about 10 quintals then how many times is the elephant heavier than the mouse? (page 91)

It can be argued that visiting temples and worshiping gods is a routine experience for children. But it is not highlighting of everyday practices of the tribal communities whose children attend SSM schools in large numbers. Names of the Hindu deities, the mythic characters – Radhaji, Rangji, Dwarikadhish, Vishwanath, Indra and Ganesha – appear as real-life characters. But the ‘lesser deities’ of the tribal children do not find any mention. The word-problems not only appear to rob the tribal children of their culture by keeping silent on symbols pertaining to their culture, but are also imposing upper caste Hindu deities on them. In fact, the textbooks do not acknowledge tribal communities, they call them as *vanavasi* (forest dweller), a term specifically used by RSS in its sanitising activities among tribal groups. Even though freedom of worship is a right in India, mention of only upper caste deities implies them to be a part of the ‘normative’ right.

Gender and SSM Textbooks

We consider another set of word-problems to discuss how gender is created and reproduced in the textbooks:

4. For the marriage of his daughter, Ramendra took loan of Rs. 25000 from his provident fund on 7th March 1999 at the rate of 13% p.a. He repaid the loan on 12th October 1999. What is the amount of repayment? (grade V, page 74)
5. 426 brothers and sisters learn in a school out of which 142 are sisters. what is the ratio of brothers to sisters? (grade V, page 73)
6. Geeta and Seeta met in the temple. Geeta told Seeta that she would visit the temple on every second day on the same time. Seeta said that she would not be able to make it every second day but would visit the temple every third day at the same time. If they met in the temple on 31 August for the first time, on which days would they meet in the month of September?

Throughout the textbooks all children receive a peculiar mention as *bhaiyya* (brother) and *didi* (sister). Children as young as 6 to 11 years old are never imagined as friends or simply boys and girls. It indicates that these textbooks have a peculiar tendency of permitting only a ‘pious’ relationship between opposite

sexes, even though the same textbooks celebrate Krishan and Radha who, according to the same mythological stories, shared a relationship outside their marriages.

Usually, a problem discussing about borrowing and lending at some interest rate could think of many situations in which such monetary transactions take place. But the textbooks borrow for 'marriage of a daughter'. It subscribes to a prevalent thinking that marrying the daughter is a responsibility of the father (and as a flip side, controlling her sexuality is his right). Moreover, even if one is debt-laden, one has to marry one's daughter observing minimum standards of celebration. Marriage and dowry are two important reasons why daughters are considered as *boz* (burden) in families in the Indian psyche. The SSM books simply strengthen this thinking by creating such situations in the word-problems.

Another and more interesting story is that of Seeta and Geeta (problem 6 above). It is used to teach LCM and the calendar. In all the SSM textbooks of Mathematics, women and girls are rarely present in word-problem and if they are, they are largely confined to domestic spheres performing the 'traditionally acceptable' roles for women. If at all they move out of their domestic limits, they go as far as the temples or on pilgrimage as good devotees. At best they may go to buy groceries. Word problems on profit-loss, interest, ratio-proportion clearly indicate that women and girls do not get involved in any meaningful financial transaction neither do they own any property or goods. All transactions involving money (be it selling cows or lighting some temple or borrowing money from bank) are restricted to the masculine gender. The only scholastic activity women do even within their domestic confinement is reading certain pages of holy texts like *Ramayana* or *Bhagavdgeeta*. The textbook girls and women possess high moral character, remain chaste especially if they are devotees of upper caste Hindu gods and spend their lives performing *seva* (service) of gods and men-folks. Such confinement of women to domesticity and their limited exposure to external world only in the form of temples and pilgrimage severely restricts entry of 'real' women from 'real' world in the textbook. Even if visiting temples and traveling for pilgrimage is a part of lived reality of women and girls in the local milieus, there are major other lived experiences that are completely ignored. Women in the geographies where these textbooks are circulated are involved in large range of labour-based activities outside their domestic worlds. These include farming, hunting, working on construction sites, milking domestic animals including buffaloes (not only holy cows, a favourite animal of these textbooks), managing small shops, teaching, nursing, and so on. On this background the selection of only particular type of experiences neglects their knowledge, skills, labour, ownership, and meaningful transactions. Such selections become further problematic considering that the tribal children come from families that may not be soaked completely in patriarchal ideology as the textbooks are.

This analysis, juxtaposed with aforementioned analyses by Chauhan (2011, 2012), Sundar (2004), clearly establishes the misogynistic nature of SSM textbooks. Textbook ignorance of existing higher levels of gender equality among tribal societies which is actually a lived reality for children and its imposition of Brahmanical patriarchy even in the most 'objective' of the school subjects, amounts to setting up a clear example of hidden curriculum. It is coherent with the overall project of the right-wing. Ironically, it coincides with the agenda of textbooks from Pakistan (Halai, 2007), the 'perceived enemy' being used by RSS and SSMs to build a 'Hindu Nation'.

HINDU WAY OF LIFE – THE PRESCRIBED NORMATIVE

The textual persecution of multicultural reality of India becomes severe when upper-caste Hindu practices appear with meticulous details for all kinds of learners in these textbooks. Consider the opening paragraph on page 87 of grade V textbook. The chapter is meant for teaching Traders' Accounts.

7. Description of trade rituals (*Vyapaar Vidhi*): On an auspicious day, the first thing to be done is to draw a picture of the deities Ganesh and Laxmi and write the holy chanting on the accounts book and then to worship it. Then credits will be written everyday on the left hand side and the debits will be on the right hand side.

It is clear that the very first line of the above description does not have any connection with the accounts one would write 'mathematically'. Such descriptions of sacrosanct status are meant for prescribing 'normative culture' through textbooks and are meant to show 'correct' ways of life, thereby establishing supremacy of dominant cultures. This description reminds me of the work of Julia Kwong (1988) on Chinese mathematics textbooks. With the help of suitable word-problems Kwong discusses how Chinese Mathematics textbooks, particularly from the late 1960s to early 1980s, were sites of dishing out political ideology rather than being mathematical artefact or instruments. For example -

> The proletariat revolutionary faction in the Red Flag Printing Company was filled with the proletariat love of Chairman Mao. As a part of their contribution to their national day celebration, they enthusiastically printed pictures of Chairman Mao. They printed 4392 copies in the morning and 5608 copies in the afternoon. How many could they produce in one day? (Textbook of Mathematics of 1969 quoted in Kwong, 1988)

Irrespective of the concepts to be taught, the SSM textbooks show high tendency of detailing only upper caste Hindu practices. We may observe how the problem of simple addition of liquids comes in through the route of a temple or home based institutionalised practice of worshiping Hindu gods. Consider the following problems.

8. 200 litre milk, 5 litre honey and 10 litre *gangajal* (holy water of river Ganges) were used to make *panchamrit* (holy mixture of 5 liquids 3 of which are derived from milk of Holy cow) on the day of Janmashtami (birth day of Lord Krishna). If 50 litre curds and 10 litre *ghee* (clarified butter) were used, what was the total quantity of *panchamrit?* (grade IV, page 92)
9. Ekata sister's mother (Ekta *bahin ki mataji*) prepared 2 litre *charanamrit* on the day of Janmashtami. She used 300 ml milk, 100 ml honey, 150 ml curds and the rest *gangajal.* How much *gangajal* did she use? (grade III, page 93)

The above problems carry an intrinsic assumption that all teachers and learners know what *charanamrit* or *panchamrit* is, and they even have the knowledge of its recipe. Such normative assumptions appearing in the prime source of 'valid knowledge' called textbooks, lead to assertion of superiority of the culture that follows such practices. Coming to think of reception of such problems, it is possible that learners from marginalised sections including tribals may not be aware of the cultural 'context' of the word-problem. They are put to disadvantage as they need to learn both the context and the mathematics incorporated in it. For instance, in

domestic settings the *charanamirt* is usually prepared by the mother; but in example no. 8, the subject is not present and the volume of *panchamrit* suggests some other setting. The proper names of girls used in examples always have an epithet *bahin* (sister), as found in example no. 9 above, which teaches learners that all girls are sisters, particularly of the school-going boys. As discussed earlier, it appears that inter-personal relations like friendship between opposite sexes is forbidden in the textbooks of SSM.

Word-problems describing religious symbols of upper caste Hindus appear so frequently that one can sense an agenda of prescribing 'Hindu way of life' as the only 'worthy' way of life. These symbols are primarily related to unquestioned devotion to god, religious texts, religious practices and rituals.

10. Distance from Hathras to Mathura and Mathura to Vrundawan is 36 km 450 m and 10 km 170 m respectively. Suresh *bhaiyya* (elder brother Suresh) went from Hathras to Vrundawan for *darshana* of Banke Bihari (bow before god Banke Bihari). How much distance would he need to travel? (Grade IV, page 83)
11. The book of Ramayana contains 1272 pages. If Rohit's mother (mataji) wants to finish reading Ramayana in 12 days then how many pages should she read every day? (Grade III, page 58)

The task of adding distances or division of 4-digit number by a 2-digit number also requires reference to places of pilgrimage or holy texts of upper-caste Hindus. If one claims that the names of 'real' places are mentioned in problem statement 10 above, shouldn't the distances also be 'real'? Nowhere in India are distances between two towns measured to an accuracy of 10 meter. Moreover, the problem can talk of real places but why would the reason of travel be Banke Bihari's *darshan*? Can Suresh not be simply Suresh, without the imposed brotherhood through the word *bhaiyya* and travel between these places without visiting Banke Bihari? Can Rohit's mother not read any other book, for getting information, knowledge or sheer entertainment with a target of finishing it in certain number of days? Is it necessary to tie her ability to read to devotion, to surrendering to a religious symbol?

MILITARISATION AND *SANSKARI* HINDU PURUSHA

Other popular choice of contexts in SSM Mathematics textbooks is contexts related to the military. One finds problems of division based on deploying soldiers on border to respond to an attack, deporting soldiers from one place to another, etc. appear as 'normal' contexts. Descriptions surrounding the actual arithmetic in the word-problems have plenty of cultural references that point in the direction of a Hindu nation. The cultural world minus the maths in a maths text book is a homogeneous nation. The calculations children are supposed to make are meant to calculate amount of *prasad* (holy food) distributed after worshipping idols, to understand how the rituals around new account books of Hindu traders are performed, to underline the stereotype and highly patriarchal family by computing expenses for sister's marriage, sum up total number of devotees visiting Kumbh Mela, and so on and so forth. The objects taken for calculations have a religious meaning for instance, cows, pages of Ramayana, frequency of visits to the temples, flags. If a floor is to be remade, it would be in the temple of the deity Hanumana. If a woman (read mother) is preparing some food item, it would be for offerings to the god. The women would piously observe Brahmanical Hindu traditions and rituals.

It is clear that Indian values and traditions are equated with values and traditions of upper-caste males by RSS and its allies. As SSM proclaims it (SSM, 2019) –

> The child is the centre of all our aspirations. He is the protector of our country, Dharma (Religion) and culture. The development of our culture and civilization is implicit in the development of the child's personality. A child today holds the key for tomorrow. To relate the child with his land and his ancestors is the direct, clear and unambiguous mandate for education. We have to achieve the all-round development of the child through education and sanskar i.e. inculcation of time honored values and traditions. (SSM Website: http://saraswatismp.com/about-us.php)

DISCUSSION AND CONCLUDING REMARKS

Molefi Asante presents a concept of centricity which means "a perspective that involves locating students within the context of their own cultural references so that they can relate socially and psychologically to other cultural perspectives." The concept of centricity can be applied to any culture. According to Adante, "for the white students in America, this is easy because almost all the experiences discussed in American classrooms are approached from the standpoint of white perspectives and history" (Asante quoted in Tate, 1998). It appears that the SSM textbooks discussed above provide such centricity to upper-caste Hindu children although such children coming from upper caste or class may not even bother to go to schools like SSM. But since the project is to develop child through '*sanskar*', SSMs that perpetually valorise upper-caste culture cannot think of the 'real' learners in their schools and their culture. Kancha Ilaiah (1996, 7) discusses in his autobiographic reflections, young learner's alienation due to cultural disconnect with content of schools.

> We (dalit-bahujans) knew nothing about Bramha, Vishnu or Eswara until we entered school. When we first heard about these figures, they were as strange to us as Allah or Jevoha or Jesus were.

Such a disconnect between the lived realities of learners and curricular content may lead to alienation among children from marginalised communities and push them into glorified traditions of the Hindus. SSMs, where "People began to send their children to these schools in preference to christian convent-schools and over so-called public schools. In Saraswati Shishu Mandirs the children could learn about their Hindu culture" (SSM Website), proclaim their agenda to use textbooks as tools of proliferation of the so-called Hindu culture which is highly patriarchal and bramhmanical in its character. Considering that these schools are not much controlled or regulated by the state, the curricular agenda itself leads to overt indoctrination and not education, even if education is imagined in instrumentalist way, leave alone what was advocated by Jotirao Phule (1827-1890) or Paulo Freire (1921-1997) as vehicle of emancipation from oppression. One wonders if there is any need to even look for the hidden agenda in SSM textbooks. In case of Mathematics textbooks of SSM, although the overarching framework is that of capitalist economy evident through the ways concepts like profit-loss, percentage, interest, traders' accounts, etc. are developed, there is no sight of even 'superficial' neutrality or modernity or attempt to shed off prejudices like many other modern textbooks of school mathematics developed for protecting interests of capitalist economies. The agenda is adequately clear – development of a *sanskari* (cultured) Hindu as against a critically thinking citizen of India.

Textbooks may be considered as passive teaching-learning materials but when children interact with them, they become active learning instruments. Thus, when students attempt to solve word-problems from SSM textbooks, what they would get even before arriving at a solution is the cultural packaging woven around the numbers. Even if a student is not able to solve a problem, can certainly grasp cultural messages like visiting temples, worshiping gods, being confined to domestic spheres (in case of female students), and so on as the desirable way of life. Considering the overall school culture in India, it is unlikely that SSMs or most other schools leave any scope for children to reject the cultural world presented formally by schools. NCF, while supporting inclusion of local knowledge and traditional skills in schools, puts a condition that "all forms of local knowledge must be mediated through Constitutional values and principles." (NCF, NCERT, 2005 B, 32). Children's Right to Free and Compulsory Education Act, 2009 (RTEA) also 'guarantees' a curriculum abiding by the values enshrined in the constitution. The irony in case of SSM textbooks is that although the word-problems are packets of regressive ideology and full of prejudices, establishing them to be 'anti-constitutional' in a legal framework is a tough task. As discussed above, one can show that the textbooks appearing in the form of word-problems are statusquoist, ignorant about cultural practices of marginalised sections (deliberately or otherwise) and prejudiced against women. There is no intent of challenging any of the prejudices, the textbooks rather try to cement the ones existing among children's minds. The problem particularly becomes intense when such textbooks are read in the light of Draft National Education Policy 2019 which advocates for schools to have their own curricula and textbooks. One possibility of what can happen in the present political scenario is foretold be the SSM textbooks.

The issue in case of word-problems is that there may be textbooks which appear 'progressive' but yet protect interests of hegemonic groups in hidden ways, paying lip service to other cultures. Bright (2017, 8) warns us against this tokenism, this "superficial treatment of "multiculturalism" that focuses on the addition of people of color" and suggests that such inclusion "may in fact be working against some of the primary goals of a socially just society by tokenizing individuals and groups without any direct movements towards challenging the shifting other aspects of the status quo."

Way Forward

I have provided examples from SSM textbooks showing how cultural prejudice is carried even in Mathematics. The problem of narratives in mathematics textbooks becomes further complicated when identifying undercurrents becomes difficult. A case in point is a recent textbook by Maharashtra State Bureau of Textbook Production and Curriculum Research, popularly known as Balbharati, an autonomous body under Department of School Education in Maharashtra. Balbharati is responsible for textbooks reaching more than 18 million children from more than 90,000 schools in Maharashtra. In recent revision of textbooks, Mathematics textbooks have adopted a style of conversation among students and teachers leading to development of various concepts. In one section of a chapter on Measurement (Grade IV, 2016) a boy goes to fetch grocery and in another section of the same chapter, another boy observed milk being served in cups. The chapter develops in the form of conversation in domestic setting and in both sections the person conversing with the boys are their mothers. The same textbook, while teaching pictorial representation of numerical information uses male faces to represent 'farmer' or 'student' which could be considered as neutral occupations. In last decade or so, word-problems in textbooks of Balbharati, have moved fairly ahead from habits of 'missing

women completely' or 'confining them only to shopping', but bringing women in domestic narratives restricts the movement. Representing farmer or student as a male shows how an opportunity of challenging prejudices is missed or how prejudices are perpetuated.

With thorough analysis of 'voice' or linguistic discourse presented in mathematics textbooks through choice of verbs, pronouns and other grammatical forms, Herbel Eisenmann (2007) emphasizes the need for mathematics educators to consider deeply "the way in which language indexes a particular ideological stance" and appeals that "curriculum developers and mathematics educators need to consider more carefully what ideological goals underlie curriculum materials." As teachers and educators of mathematics, we must remember that the numbers in the word-problems may be unrealistic or irrelevant but the contexts may be real. If the contexts are not coherent to the lived experience of children and if they hesitate to challenge stereotypes embedded in those contexts or otherwise, textbooks meant to teach the so-called objective school-subject may turn out to be tools to reproduce socio-cultural inequalities. If we agree with the vision of the position paper of National Focus Group on Teaching of Mathematics (NCERT, 2005 C, vi) that "all students can learn mathematics and that all students need to learn mathematics" then we need to acknowledge that contexts presented in word-problems need to be locally relevant and progressive in their social outlook. Failure in making them locally relevant may continue perception of mathematics as the most difficult and irrelevant subject while failure in creating progressive contexts with multiple realities may make mathematics a vehicle of social inequality and subbordination. As teachers and educators of mathematics, we need to be cautious about both of them.

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