Textual Texture of School Science

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Abstract Textbooks provide a vital curricular input that guides and establishes the academic setting for the teaching–learning process in India. They constitute the primary means through which legitimately endorsed knowledge in a subject comes to be disseminated by the curriculum framing agencies and consequently accessed by learners. They occupy a significant place in the educational process, especially in the case of a country like India which faces a huge number challenge and acute resource constraints, and where textbooks are the chief sources of valid knowledge, not only for students but also for teachers. Representation of knowledge in textbooks is, therefore, a crucial factor in shaping a large number of students' conceptual understandings, views and stances, and therefore need to be closely scrutinised. Presentation of the content, form, style and language of the textbook are all indicative of the specific position held about the nature of the learner, the nature of the subject matter and pedagogy. This position, however, is not overtly articulated, rather it has to be inferred and analysed. Making these textual tendencies visible would help major stakeholders in education assess them in light of contemporary understanding of education. This chapter is an attempt to closely examine the National Council of Educational Research and Training (NCERT) prescribed textbooks from class III to class X, to decipher their content and to analyse: (i) what their view of the subject matter is, (ii) how they situate the learner and (iii) on what pedagogical considerations they are premised. Textual tendencies are then traced across classes, moving vertically up the academic ladder.

Introduction

The use of textbooks in schools is probably as old as the phenomenon of formal schooling itself. While there has been a wide acknowledgment of the need to diversify curricular material, it simultaneously holds true that textbooks continue to be primary propellers of the curriculum. Especially in a number-challenged and

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resource-constrained country like India, textbooks ‘represent to each generation of students an officially sanctioned, authorised version of human knowledge and culture’ (Luke, De Castell, & Luke, 1989, p. viii). They are the key mediators between the intended and the enacted curriculum, and in that sense legitimise the national education discourse. Textbooks, through their presentation and style, put forward the state-endorsed view of the discipline. Since they are the sole available source of ‘valid knowledge’ for a substantial majority of Indian children and given the observation that, in many instances, the textbook may be dogmatically followed by teachers, the views presented in these texts need to be articulated, examined, analysed and critically discussed. Textbook analysis has emerged as a fertile area of research with studies of various types concentrating on a range of aspects, such as content and teaching methods, language and readability, assessment and evaluation, societal issues, illustrations, epistemologically oriented issues, holistic approach and reviews (Dimopoulos, Koulaidis, & Sklaveniti, 2005).

There has been a growing concern about the depiction of ‘science as static, finalistic, a historic, beyond doubt, universally applied knowledge, discovered by intelligent, individual scientists with no self-interest, after powerful efforts, which are ultimately crowned with success’ (Dimopoulos & Karamanidou, 2013, p. 61). Such an image is unrealistic and misleading. The question of whether science textbooks should only be about facts and currently accepted theories or should also concern themselves with the issue of communicating how these were arrived at and how scientific knowledge is created in human contexts may be treated as settled. Various educationists who have grappled with the issue have concluded that both the aspects merit importance in a curricular resource as fundamental as the textbook.

This chapter does not attempt or claim to undertake a detailed, dimensional review of textbooks on a pre-determined grid or a framework. Rather, it tries to take a more panoramic view. It looks at school science holistically, as depicted in textbooks, from four major vantage points- its placement within the curriculum, its depiction as subject matter, its portrayal as a human enterprise and in terms of its learner responsiveness. It describes the textbooks being currently prescribed by the National Council of Educational research and Training (NCERT) at primary, upper primary and secondary levels and tries to gauge and make explicit from these, through substantiating evidence, the national stance towards science pedagogy. In India, NCERT is the apex body responsible for formulating and articulating a national vision for school education. It is associated with the processes of curriculum development and textbook writing. The textbooks developed by the Council serve as exemplars for states and are therefore instrumental in preparing the nation-wide academic setting of a given school subject.

Science in Indian School Curriculum

Influenced collectively by the colonial push for western knowledge, the Nehruvian vision of modernity and the emergent need for skilled workers in a newly technologised society, science has always been accorded a prime position in the school curriculum in post-independence India. Science was seen as a way forward in building a new India and the theme recurred in the speeches and writings of national leaders as evidenced in the following articulation by Jawaharlal Nehru:

> Science is the spirit of the age and the dominating factor of the modern world. Even more than the present, the future belongs to science and to those who make friends with science and seek its help for the advancement of society. (Gopal, 1976, p. 806)

The discipline of Science in the Indian school system has also always been saddled with a lot of responsibility. It is frequently thought of as being the key to development of the nation. It is supposed to inculcate rationality and 'scientific temper', raise informed citizens, develop problem-solving skills and consequently liberate the citizenry from the 'vicious circle of ignorance, poverty and superstition' (NCERT, Position Paper-National Focus Group on Teaching of Science, 2006) Consequently it forms an important part of the syllabus for all classes. It also enjoys the reputation of being an intellectually elitist discipline, not easily available to everybody. Children desirous of taking up science as their choice stream of study in class XI often have to demonstrate their suitability by scoring a certain minimum number of marks in their class X examination.

Broadly the formal Indian school system is vertically tiered into 4 stages- Primary (classes I–V), Upper Primary (classes VI–VIII), Secondary (classes IX and X) and Higher Secondary (classes XI and XII). Evidently, influenced by the cognitive developmental view, the textbooks written for a specific stage, irrespective of the particular class, are similar in terms of their treatment of the content and writing style. Science as an exploration of the natural world is included within the realm of 'Environmental Studies' (EVS) at the primary stage. EVS is a composite area of study premised on the understanding that young children interact with their environment holistically and, therefore, it is unnatural for them to compartmentalise knowledge into watertight boundaries called 'subjects'. It, therefore, includes, within its purview, the study of the natural as well as the social environment of children. Textbooks are prescribed from class III onwards. Science as a separate subject, with a separate textbook, appears as part of the school syllabus at upper primary and secondary level. At higher secondary level, it becomes further branched into Physics, Chemistry and Biology with separate textbooks for each of these areas. This further fragments the understanding of the world into specificities, a phenomenon recognised as specialisation at advanced levels of education.

The Content of Science

It is easier perhaps to describe rather than define science. As a body of knowledge, it includes within its purview the various facts, principles, laws, theories and explanatory frameworks which are helpful in making sense of the natural and physical world around us. As a way of doing, it involves the various experiments and activities that are carried out during exploration and formulation of descriptions of the ways in which nature functions. As a way of thinking, it encompasses the various ideas, conjectures, hypotheses, predictions, estimations, claims, and refutations that are made during the course of investigations. A more succinct comment on science can be drawn from the position paper of the National Focus Group on Teaching of Science (2006) formed by the NCERT. The paper observes that the discipline of science involves

> observation, looking for regularities and patterns, making hypotheses, devising qualitative or mathematical models deducing their consequences, verification or falsification of theories through observation and controlled experiments, and thus arriving at principles, theories and laws governing the world… The laws of science are never viewed as fixed eternal truths. Even the most established and universal laws of science are always regarded as provisional, subject to modification in the light of new observations, experiments and analyses (p. 1)

To be truly representative of the discipline a textbook needs to depict and communicate all of its features to students. It should familiarise the students with the various concepts which have helped humanity make better sense of the natural world and how it functions. It should facilitate learners' acquisition of the methods and processes through which scientific knowledge is generated and validated and also help them to appreciate how our present understandings are the result of a long conceptual struggle and evolution. Examining the identified textbooks informs us that all the three aforementioned aspects are duly represented at the three stages. Observing, hypothesising and question-raising are skills that find due mention and representation across all grades and stages. The textbooks at the primary level constantly encourage children to think, discuss, debate, write and share ideas. Learners are persuaded to observe and question the happenings around themselves. The textbooks at primary level present the content through questions and activities. At the secondary stage too investigative activities are suggested at suitable junctures. What does not seem to get emphasised at higher stages is the cognitive effort and rigour required to plan investigations.

Science as a Community Constructed Enterprise

The history of science informs us that building scientific understandings is a non-linear process (Kuhn, 1962). Ideas are proposed, at times on the basis of experimental evidence or on the basis of creative insights, tried out, reworked, challenged, countered—leading to conceptual tensions which may not always be resolved. However, scientific knowledge can sometimes be presented in the textbooks as 'given' and static rather than as evolving and dynamic. Presentation of science as a systematic, linear process which always leads to definite answers can be misleading. A textbook which is true to the nature of the discipline must introduce it to its readers as an essentially human enterprise so as to break the alienating 'exclusivity' that is often associated with the subject. This would also be helpful in placing the subject within the intellectual ambit of children, who are then more likely to pursue the subject at higher levels of study. There are three ways in which the human ownership of scientific knowledge could be factored into the textbooks: bringing out the quest for knowledge as a shared human need which necessitates exploration and creation of both technology as well as concepts, use of historical instances to trace and highlight conceptual struggle, and highlighting the role of consensus in arriving at scientific knowledge. Spelling out the contexts in which particular concepts emerged is as important as highlighting the societal need for sophisticated technology. Sometimes the technology itself can catalyse concept formulations. For instance, the term 'work' was first used in connection with the use of steam engines to lift buckets of water out of flooded iron ore mines and came to be equated with weights lifted through certain heights. Bringing in these little details can facilitate the cultivation of significant disciplinary insights among students. There have been many proponents who have made a strong case for inclusion of the historical development of science in textbooks in order to promote scientific literacy and understanding of the structure of 'scientific method'. Cognitive theorists identify two primary categories of knowledge - declarative and procedural (Anderson, 1980, pp. 177–179). Declarative knowledge in science consists of facts, laws and theories that state how we presently explain the world and its phenomena. Operational knowledge is an appreciation of how these explanations were arrived at and what persuades us to collectively favour one explanation over another. If we agree, in principle, that science textbooks should concern themselves with inculcating both these kinds of understandings among students, then the entire book ethos has to be informed by this outlook. We may read the textbooks to find out whether the tone of the text, as demonstrated in its sentence construction, is declarative or procedural. For example, Fig. 1 shows a piece of text from a class VII textbook which tries to explain the role of leaves in food preparation for the plant.

While the concept of food preparation by plants has been brought in through a question, the answer is provided directly without any helpful information that could help children appreciate how the answer could possibly have been arrived at. The tone, therefore, remains authoritative. We find that though there is a visible attempt in several places to introduce students to the processes of knowledge building in science, there are several other places to which this idea has not been extended. What also

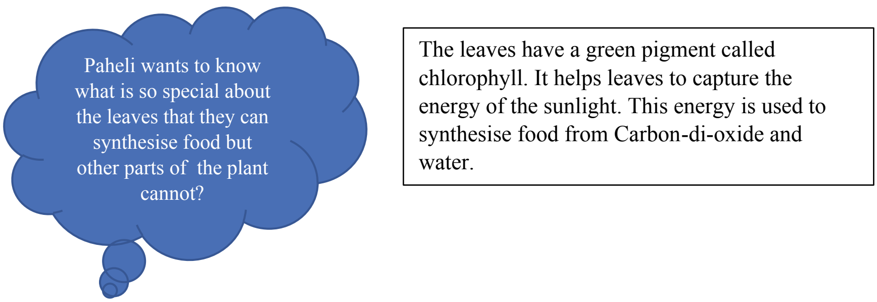

Fig. 1 Role of leaves in food preparation of plants

need to be communicated to students are the gaps in our present knowledge and the efforts that are currently underway to fill these gaps. Introducing students to these aspects would be more in tune with the dynamic nature of science.

This assertion can be illustrated by tracing the idea of water and mineral transport in plants as it is presented at a secondary level. In class IX, students are introduced to the structural details of the xylem tissue in the chapter titled 'Tissues' in these words:

> …complex tissues are made of more than one type of cells. All these cells coordinate to perform a common function. Xylem and phloem are examples of such complex tissues…Xylem consists of tracheid's, vessels, xylem parenchyma and xylem fibres… (p. 73)

In class X the topic appears as part of the chapter' Life Processes' under the subtopic 'Transportation in Plants'. The explanation of the phenomenon is initiated by first talking about the movement of water and minerals into the roots due to a difference in concentration of ions between the root and the soil which creates a water column by providing a steady push. Rationalising that this pressure by itself will be insufficient to account for water transport to the higher plant parts, the text then goes on to explain the process of transpiration

> However this pressure by itself is unlikely to be enough to move water over the heights that we commonly see in pants…Plants use another strategy to move water in the xylem upwards to the highest points. Provided that the plant has an adequate supply of water, the water which is lost through the stomata is replaced by water from the xylem vessels in the leaf. In fact, evaporation of water molecules from the cells of a leaf creates a suction which pulls water from the xylem cells of the roots. The loss of water in the form of vapour from the aerial parts of the plants is known as transpiration… (NCERT, Science-Textbook for class X)

Some significant aspects of the water transport phenomenon that are clarified through these explanations are: Root pressure as well as the suction in leaves are responsible for water transport. By reasoning that root pressure itself may not be sufficient to explain the phenomenon of water transport, the text is hinting at the thought processes which underlie the search for explanations of different phenomena. Then by defining transpiration as 'loss of water in the form of vapour from *aerial parts*', it is clarifying that transpiration could also occur from other photosynthesising structures of the plants.

The linguistic formulations are however declarative. The explanations do not attempt to portray the collective research efforts which allowed scientists to arrive at our present knowledge. This could have been brought in through a brief description of how the cohesion-tension theory originated at the end of nineteenth century. A mention of the fact that some aspects of the cohesion-tension theory still require experimental validation (Kim, Park, & Hwang, 2014) could have highlighted the dynamism of scientific knowledge. The topic also provides scope for building interdisciplinary connections through discussion of capillary action. Available research on children's ideas of the phenomenon of water transport shows that children hold an inadequate understanding of the concept (Barker, 1998). More specifically, most children are found to believe that most of the water that plants absorb is used up for preparation of food through photosynthesis (Çokadar & Özel, 2008). A reference to the fact that plants lose enormous amounts of water through transpiration does appear in class VI but is not revisited here (Science-Textbook for class VI, p. 139). Drawing children's attention to relevant details of transpiration could be helpful in addressing this idea. A well-rounded approach would be one that deals with a given topic in totality and looks at it from all angles.

There is a noteworthy attempt by the textbooks to highlight the role of the *collective* in defining concepts. This is evident in sentences of the following type taken from the class IX textbook:

> The word energy is very often used in our daily life, but in science **we** give it a definite meaning' (emphasis added) (p. 149) and 'To understand the way **we** view work and define work from the point of view of science… (emphasis added) (p. 147).

Locating the Learner

The sociological context of science has been brought into focus with the help of robust arguments put forward by many people who have engaged with the subject (Kuhn, 1962). It has been convincingly demonstrated that the practice of science involves people whose work is value-laden and socio-culturally contextualised. Consequently, a strong case has been made for science education in socio-cultural contexts (Kelly, Carlsen, & Cunningham, 1993). Even teachers are found to develop a more empowered attitude to science when scientific concepts are located in familiar and relevant contexts (Plonczak, 2008). It follows that there is a need to communicate science in familiar contexts to make the formal knowledge personally meaningful to children. Textbooks can begin by making an attempt to actively acknowledge that the learners, who constitute the readership of these textbooks, are situated in a multitude of specific life situations. Whether textbooks attempt to embed concepts in contexts may be gauged by looking at four aspects of content presentation: whether the content is mediated through characters, whether the understandings to be communicated have been woven into appropriate narratives (real life or otherwise), whether the characters in the narratives are placed in specific socio-cultural situations and whether the contexts chosen are pluralistic. What also merits attention is how the scientists and their work is represented within the textbooks. The following is an excerpt from the chapter 'Experiments with water' in the class V EVS textbook.

> Ayesha was waiting for dinner. Today Ammi was making her favourite food-puri and spicy potatoes. Ayesha watched as her mother rolled out the puri and put it in the hot oil. She saw that at first the puri sank to the bottom of the pan. As it puffed up, the puri came up and started floating on the oil. One puri did not puff up and did not float like the others. On seeing this, Ayesha took some

dough and rolled it into a ball. She flattened it and put it in a bowl of water. Alas! It sank to the bottom and stayed there.
Think what would happen if

- Ayesha put a puffed puri in a bowl of water. Would it sink or float?
- Would the cap of a plastic bottle sink or float in water?
- What would happen to a spoon?

The concept of floating and sinking could well have been communicated by asking students to recall observations from their daily lives and then making them carry out activities to find out which objects sink or float in water. However, embedding understanding in a familiar context could help to forge an organic connection between science and students' everyday lives. It is evident from the above excerpt that in this chapter children, through the example of Ayesha, are taken through various processes of science such as observing, hypothesising, reflecting, investigating, predicting and so on to encourage them to reflect upon the various factors that could determine the sinking or floating of objects in water. Researchers across countries have reported that there is a wide prevalence of certain stereotypical ideas about science and scientists. That is, people usually have a set view about what science is, how science is done, who does science and where science is done (Chambers, 1983; Mead & Metrax, 1957). The presentation of Ayesha as the investigator, in the example above, could be helpful in confronting various stereotypical ideas, such as scientists are usually middle-aged males, science can only be done in special environments like the laboratory and science requires sophisticated apparatus.

Science textbooks at the upper primary stage continue to be activity-based. The material required for performing these activities is likely to be chosen from items that are easily available and accessible to children. The illustrations that appear alongside the text depict both boys and girls. The questions whose answers can be answered through the text are frequently mediated through sketches of two children, a boy called Boojho (translates as Solve) and a girl called Paheli (translates as riddle) who appear from time to time and raise questions. The text suggests activities or provides explanations and clarifications which would lead to the answers to these questions. The text is addressed to the reader (a student of an upper primary class) but not to any specific reader. Paheli and Boojho ask many questions in upper primary textbooks, some of the interesting ones being: '*how could a single cell become such a big individual*'? (Science textbook for class VIII, p. 104) or when Paheli wondered how time was measured when pendulum clocks were not available (Science textbook for class VII, p. 148). There is a visible attempt to use children's natural curiosity as a springboard for introducing science concepts.

'Paheli' and 'Boojho' disappear at the Secondary stage. The writing style remains conversational at this level, and the textbook proceeds by citing examples from daily life, raising questions and providing explanations. First person 'we' is used whenever an activity is suggested or a clarification is given, implying that the authors are working together with the students in their exploration of the world.

Tracing the Tendencies

The discussion so far has tried to articulate the various vantage points for looking at scientific knowledge within the texts and has dwelt upon some broader considerations. It would be pertinent now to look for the emergent patterns about disciplines and related pedagogies as reflected in the textbooks. This section tries to map the picture of science as it emerges at the secondary level and the disciplinary image that is likely to be formed in the minds of class X students as they stand at the threshold of making an academic stream choice in class XI. Certain conclusions are drawn and corroborating evidence is also provided in many places.

Disciplinary Versus Integrated Approach

Traditionally there has existed a consensus among educators about the need for early school science to be integrated and division into separate specialisations to appear later but there have been different views about the nature and the appropriate time for these divisions to be introduced. The Kothari Education Commission (GOI, 1966) recommended the holistic study of the environment as EVS up to grade IV and branching into separate subjects from grade V onwards. The commission opined that the general science approach had not been successful because it made science appear 'formless and without structure' and ran contrary to its methodology (p. 198). The National Curriculum Framework (1988, p. 25) proposed that Environmental Studies be taught as a composite subject in classes I and II and split into EVS I and EVS II in classes III to V- one devoted to science and the other to social science. The National Curriculum Framework (2000) recommended Environmental Studies to be taught in primary classes and science and technology and social sciences to be introduced at upper primary level (p. 30). Presently, in accordance with the vision of the National Curriculum Framework (2005), Science is taught as EVS up to class V (p. 48) and as Science from class VI onward with a separate textbook. EVS is a composite area of study with scientific and social concepts woven around six core themes that run across the EVS syllabus of classes III to V. These are: family and friends (which includes four sub-themes: relationships, work and play, animals, plants), food, water, shelter, travel and things we make and do. To take a more holistic view, the science curriculum of classes VI–X is also founded on six broad areas: food, materials, the world of the living, moving things, people and ideas, how things work, natural phenomena and natural resources. 'The choice of themes and sub-themes reflects the thrust towards weakening disciplinary boundaries which is one of the central concerns of NCF-2005' (NCERT—Syllabus for Secondary and Higher Secondary Classes, p. 2). Despite this well-articulated intention the textbooks at upper primary and secondary level have found it difficult to move away from the 'in-science' subject boundaries of physics, chemistry and biology. Some of the titles of the chapters are themselves a giveaway, such as gravitation (class IX), tissues (class IX), light and shadows and reflections (class VI). Science in these classes, therefore, comes across as an agglomeration of concepts taken from different subjects but bound in a single cover. The idea of integrated science in its truest sense is not demonstrated.

Pedagogic Stance Is Stage-Specific

The shift in pedagogical approach is evident from one stage to another. At the primary stage, the attempt to access concepts through particular contexts is visible. At the upper primary stage, there is an attempt to introduce concepts through use of concrete materials and activities with the illustrated characters of two children mediating the text. At the secondary stage, the tone of the textbook becomes more formal and the illustrated characters disappear but activities remain. The approach of the textbooks changes from immediate to concrete to distanced on moving up the academic ladder. Across the grades and stages, there is a consistent and visible effort to link school science with the everyday life experiences and observations of children.

Hands-on Activities and Science Learning

Anchored presumably in the ‘discovery- learning’, ‘active -learning’, ‘child-centredness’ and ‘child as a constructor of knowledge’ rhetoric, there is a visible attempt, across classes and stages, to introduce the content through hands-on activities, as much as possible. The tendency may partially be attributed to the influence of the constructivist viewpoint, according to which knowledge is not something to be delivered to learners but something which is to be personally constructed by all individuals. The National Curriculum Framework (2005), which spells out the vision on which the textbooks are based, strongly advocates the desirability of acknowledging and duly providing for the primacy of the learner in the entire process of school education. It vehemently stresses the need to make available to children opportunities that would facilitate them in constructing knowledge in a personally meaningful manner.

Occasionally this ‘construction’ appears to be considered possible only through hands-on activities. The textbooks are replete with simple, doable activities requiring inexpensive, easily available materials. Across the grades, the emphasis seems to be on making conceptual understanding concrete and visualising, a tendency which needs to be used cautiously, since not everything can be directly observed. A negation of the process of abstraction could actually forge an incomplete understanding of the concepts and methods of science. The phenomenon of light is an example of such concepts. Though ‘visible’ in the traditional sense of the term, its comprehension requires a high degree of abstraction starting right from the notion of rays, which are only a theoretical construct but drawn diagrammatically, to illustrate the behaviour of light. Similarly, force and energy are two abstract ideas which are introduced quite early in school science.

Depiction of Science as a Self-initiated Investigation

While there are a lot of hands-on activities given in the textbooks, there is little scope for students to plan investigations on their own. The textbooks do not generally expect the students to initiate investigations, especially at upper primary and secondary level.

The tone of suggested activities is largely instructive and prescriptive with little scope for students to pose problems, think of experimental designs and work on them. In many cases, the conclusions are also drawn on behalf of students.

Most of the suggested activities at the upper primary stage begin by instructing the learner to set up and perform given tasks such as

> Take a rod or flat strip of a metal. Fix a few small wax pieces on the rod……Clamp the rod to a stand…Heat the other end of the rod and observe. (Science, Textbook for Class VII, p. 40)

The text further asks the students to share their observations and then goes on to summarise the observations and draw relevant inferences. However, there are no instances in which the students are required to independently design an investigation which would help them to find answers to authentic questions, that is, questions raised by them in real contexts. The questions/problems are provided by the textbook itself and the path to finding the answer is also provided. Learners are required to follow the steps systematically.

Portrayal of Scientists

The notion of science as an endeavour of specific people gets communicated in textbooks for classes IX and X. In primary classes, science concepts are communicated through particular contexts, as illustrated in the aforementioned example of Ayesha. In upper primary classes also, science is shown as being initiated and carried forward through questions raised as illustrated by two young children named Paheli and Boojho. The readers are drawn to the content through the questions and activities of these children. For example:

> Paheli has another (different from the one suggested in the book) arrangement of the cell and the bub. Will the torch bulb glow in the following arrangement? (refers to picture given alongside) (Science -textbook for class VI, p. 120).

In secondary classes, the specific work done by scientists and the notion of scientists as a group of people working closely together, begins to get emphasised. The following excerpts would perhaps help explain this observation:

> Modern day scientists have evolved two types of classification of matter based on their physical properties and chemical nature. (Science -textbook for class IX, p. 1)
>
> For a common person pure means having no adulteration. But, for a scientist all these things are actually mixtures of different substances and hence not pure. (Science -textbook for class IX, p. 14)

We might observe that the image of scientists as special people, engaged in a special kind of work begins to take shape in the references above. Class IX and X textbooks also include biographical notes on the lives of various scientists. These appear in boxes within the chapters. An analysis of these notes, carried out with the objective of revealing the image of science and scientists communicated through them, found that there are two significant ways in which these notes challenge the stereotypical image of scientists: (i) scientists learn from each other and carry forward each other's work, (ii) scientists may demonstrate cross-disciplinary interests. However 'the image of the scientist as a stern-looking Western, hardworking male still holds and the perception of science as a laborious discipline pursued by single-minded people, largely unaffected by social factors, remains uncontested (Kaur, 2015, p. 75). Also, the tone of the biographical notes remains focussed on scientists' achievements. It may be argued that, even though extensive information and specialisation is generally considered the hallmark of science, it is also important to make science accessible to the general public, especially in face of the evidence that people hold stereotypical images of occupations and also of the people in those occupations. Preferences that individuals develop towards certain occupations may be determined by the compatibility of these images with their own images of themselves (Gottfredson, 1996).

Use of Narratives

The issues of cultural recognition and representation of various social groups in the school curriculum have led to certain visible features being incorporated in the textbooks, such as the names of characters showing cultural diversity and the visuals showing both boys and girls as performing various activities. While the need to make science culturally relevant is being articulated in all fora, what needs to be simultaneously appreciated is that there is no single context in India but many varied contexts.

Inclusion of narratives in science textbooks can be helpful in embedding science in socio-cultural contexts. They help to put names and faces to people engaged in scientific endeavours. They also help in bringing the so-imagined 'exclusive' discipline of science within the everyday reach of people. Narratives, fictitious or real, can be useful ways to challenge prevalent stereotypes about science and scientists. Textbooks at upper primary and secondary levels do not use narratives as a pedagogic device and this characteristic merits deeper reflection. One could conjecture two possible reasons for this tendency.

The first could be the nomenclature of the study area itself. At the primary level, 'Environmental Studies' is a composite discipline that draws upon both science as well as social science, and hence the subject matter may be more amenable to inclusion of specific events and historical incidents. Social sciences may be thought of as being more responsive to the socio-cultural contexts of learners. In upper primary and 'secondary' classes, the subject is termed 'science', and hence objectivity and neutrality are perhaps prioritised. People shown as doing science are therefore nameless (or have names like Paheli and Boojho which have no cultural intonations) and are contextless. This point of view resonates with the universalistic view of science that suggests that scientific knowledge has to be founded on the cognitive criteria independent of the social, cultural and personal context of the learner. This view has been effectively countered by the evidence supporting the assertion that all scientific knowledge is developed and applied in specific contexts. The decontextualised approach to the science curriculum has been contested by the proponents of the 'humanistic approach' in science (Aikenhead, 2005).

The second possible reason that one can imagine, and which needs to be better understood, would be the argument that since the textbooks are prescribed nationally in India, a country of staggering diversity, bringing in particular contexts is possible only at the expense of leaving out several others. The counter view to this line of reasoning would be that diversity in contexts can be addressed and capitalised upon as a rich resource of science learning only by making it relevant to the curriculum and not by making it invisible. Neutrality of context deprives the science curriculum of opportunities to communicate a realistic image of science. Also, it needs to be simultaneously stressed that when diversity is overlooked then the perspectives of particular groups get represented in the name of 'universalism' and this is mostly the perspective of the middle or the dominant class. Consider the following excerpt from the chapter 'Garbage in, garbage out' of class IX textbook.

> You might have seen some children, sorting the garbage near your house or at other places. Observe the children at work and find out how they separate useful material from the garbage. They are actually helping us (p. 161).

The text is obviously addressed to children other than rag-pickers. Conversely, rag-picking children are not ordinarily expected to be present in the classroom and reading science textbooks. The text thus inadvertently leads to subtle 'othering' of children from certain sections of the society.

Place for Children's Ideas

Understanding about children and their learning informs us that children come to formal science instruction with a range of prior experiences. They have many preconceived notions about the functioning of the world around them. These ideas, variously referred to as intuitive notions, children's models, alternative conceptions or alternative frameworks in the research literature (Driver, Guesne, & Tiberghien, 1985, pp. 8–9) are formed on the basis of ordinary observations and experiences. They are repeatedly reinforced in everyday encounters and are therefore extremely robust and resistant to change. Many times these notions differ radically from the scientifically accepted explanations and could pose considerable conceptual difficulty for students. A few examples of such ideas are: continuous motion requires continuous force, things become heavier as they are lifted farther up from the ground and heat is a form of fluid and so on. Traditionally, considered as unnecessary inconveniences, these ideas were largely ignored by educators. However, contemporary wisdom looks at these ideas differently. It has come to be widely admitted that charting of students' future learning paths cannot be done without first studying and reflecting upon their pre-conceptions because their future course is decided by the nature of these pre-conceptions. There is a plethora of research literature now available on children's ideas pertaining to different concepts and phenomena. The textbooks need to begin to acknowledge this research evidence and build an appropriate response. An effort in this direction is more readily manifested at primary level where children's perspectives are brought in through their conversations or by challenging their perspectives through specific activities designed for the purpose. However, consistency in pedagogy is missing, that is, not all domains are addressed in this manner. At upper primary and secondary level there is an explicit attempt to address children's ideas in some places, as in the following excerpt:

> How do we know that something is living? Often, it is not easy to decide. We are told that plants are living things, but they do not appear to move like a dog or a pigeon. On the other hand, a car or bus can move, still we consider them as non-living. Plants and animals appear to grow in size with time. But then, at times, clouds in the sky also seem to grow in size. Does it mean that clouds are living? No! So, how does one distinguish between living and non-living things? (Science-Textbook for class VI, p. 87)

The passage above is clearly targeting students' ideas about living and non-living things and is referring to the available literature on the subject.

There is also a clear attempt to address the widely prevalent and well documented current consumption model of current electricity (Shipstone, 1985, p. 35) in the chapter titled 'Electricity' in the class X science textbook (p. 219). However such efforts are very few in number.

Treatment of History Within the Textbooks

The field of education in India has actively taken cognizance of the globally well-argued need for the subject matter of school science to be suitably responsive to the historical development of the discipline. History may be seen as entering the NCERT textbooks in five major ways:

(i) General statements: These make references to the past without highlighting the specifics. For example, 'Till 10,000 B.C., people were nomadic' (Science-Textbook for class VIII, p. 1)

(ii) Specific facts: These are factual statements. For example, 'Louis Pasteur discovered fermentation' (Science-Textbook for class VIII, p. 20)
(iii) A generic tracing of history: The history of a particular object or a phenomenon or an understanding is traced without dwelling upon the specifics. For example, the story of transport (Science-Textbook for class VI, pp. 95–96), and the discovery of silk (Science-Textbook for class VII, p. 30)
(iv) Detailed instances: Specific incidents or specifics of the process of a discovery/invention or an understanding reached are detailed out. For example, the discovery of the process of digestion by Dr Beaumont (Looking Around- EVS Textbook for class V, pp. 30–31; Science-Textbook for class VII, p. 16) and the speculation about the origin of life (Science-Textbook for class X, p. 150). In addition to these the textbooks for classes IX and X also contain biographical notes on many scientists
(v) Biographical notes: These appear as boxed items and give a description of a scientist's life and/or his key contributions.

Of the five ways described above, the last two may be considered to hold considerable educative potential for communicating the nature of science. At primary level science is taught as part of EVS and deals with concepts and issues of 'science' as well as 'social science'. Historicity in the context of science makes an appearance in class V textbooks and in this book there are four detailed historical descriptions of discoveries: Dr. Beaumont's discovery of the functioning of the stomach (pp. 30–31); George Mestral getting the idea of Velcro (p. 48); Ronald Ross' study of mosquitoes and malaria (pp. 74–75); and Mendel's experiments with peas (p. 198).

The search for other episodes of these type leads us to the following instances at upper primary and secondary level: the story of the discovery of magnets by a shepherd named Magnes (pp. 125–126, Class VI); the discovery of the functioning of the stomach by Dr. Beaumont (p. 16, Class VII); the discovery that the time period of a given pendulum is constant by Galileo (p. 147, Class VII); Alexander Fleming's work on a culture of disease-causing bacteria that led to the preparation of penicillin (p. 20, Class VIII); and the story of Dolly, the cloned sheep (p. 108, Class VIII).

In addition to the boxed biographical notes on many scientists, the following instances of historically informed episodes could be identified at the secondary level: arriving at the understanding of the structure of an atom (pp. 47–49, Class IX); the chronological development of our understanding of the structure of the cell (p. 58, Class IX); the periodic classification of elements (pp. 79–85, Class X); Mendel's experiments on garden peas (pp. 143–144, Class X); and speculations on the origin of life (p. 150, Class X).

Despite this appreciable effort there does not seem to be a consistent effort to use historical instances for strengthening conceptual understanding in science. Textbooks, especially the ones at upper primary and secondary level, seem to be 'peppered' with historical references without an effort to really place any given instance at the centre and conceptually learn from it. The idea that should be communicated, besides the importance of systematic investigation, is that doing science is also about responding to incidental happenings and using them as learning opportunities. Teachers, who are the key mediators of textbooks, also need to be cued about using them. Noticeably, while textbooks at primary level provide guidelines to teachers at certain junctures, those at upper primary and secondary level do not. In the case of the structure of atom, where there is a serious attempt to approach the subject historically, the various models are presented linearly, one after the other, by giving evidence in favour of the new model and highlighting the shortcomings of the older ones. This makes the process seem neatly unidirectional without making an attempt to demonstrate the inherent revisioning of ideas and presentation of counter views, which are intrinsic to the phenomenon of knowledge building in science. This is however attempted, to a certain extent, in the case of the development of the periodic classification of elements.

Concluding Comments

In many ways, school textbooks in India do try to respond to the prevailing discourses in education. Science is depicted, in equal measure, as a way of doing and as a way of thinking. Relevant and doable activities are suggested throughout to support conceptual comprehension. Across the stages, students are constantly cued to think of reasons for particular observations or predict results. There are fewer opportunities, however, for students to devise their own ways to go about finding answers to particular questions. The activities, therefore, tend to become prescriptive. Acknowledging the current emphasis of placing conceptual understandings in historical contexts, there is an all-pervasive effort to cite historical instances which show how a discovery was made or the method of investigation followed by particular scientists, even though the approach cannot be termed as historical because it masks the conceptual struggles and messiness involved in arriving at a shared scientific understanding of the world and its phenomena. There is also no visible effort to provide alternative perspectives, however weakly supported, about any given particular explanation. Another aspect that needs more attention is the imperative to highlight that science is as much about the felt need to define new concepts as it is about discovering new things. There are also sporadic instances of the texts making an attempt to address children's alternative ideas on a subject by directly targeting them, but the approach is piecemeal instead of being consistent. It may, therefore, be concluded that while the textbooks for all classes seem to be adequately informed by contemporary thought in the field of education, what is required, perhaps, is persistence, permeation and a consistency of approach.

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